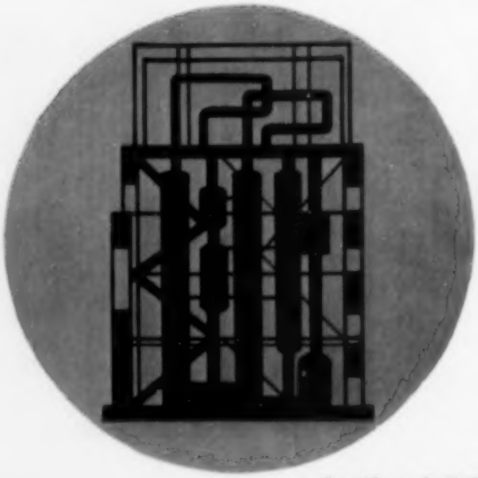
Chemical Engineering Progress

MAY 1956



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Chemical Engineering Progress

what's in this issue

May, 1956 • Volume 52, No. 5

(Continued on page 7)→

departmental features

Chemical Engineering Progress, May 1956, Volume 52, No. 5. Published monthly by American Institute of Chemical Engineers at 15 North Seventh St., Philadelphia 6, Pa. Editorial offices 25 West 45th St., New York 36, N. Y. Entered as second class matter December 9, 1946, at the Post Office at Philadelphia, Pa., under Act of August 24, 1912. Member Audit Bureau of Circulations. Copyright 1956 by American Institute of Chemical Engineers.

HERE'S
the chemical plant sifter
with stainless steel product zone

√ TO ... CLASSIFY A MATERIAL BY PARTICLE SIZE
√ ... SCREEN IT TO REMOVE LUMPS OR UNGROUND PARTICLES
√ ... SIZE IT FOR UNIFORMITY ... QUALITY CONTROL

This compact Model "M" Bar-Nun Rotary Sifter has every feature the chemical plant wants on a screening job . . . big capacity in limited floor space . . . accurate separations . . . stainless steel construction at all product contact points . . . durability.

In some plants, installation of a modern Bar-Nun has doubled or tripled screening capacity in the same floor space. Its *mechanically controlled*, full rotary motion rapidly exposes the material to a maximum number of screen openings. More than one screen in the same box multiplies capacity—or, with different mesh cloths, will make several separations in the same run.

Screens are firmly held in a dust-tight, totally enclosed box constructed of stainless steel panels, mounted on cast aluminum frames. Box is quickly opened for cleaning, or to change screens. All-mechanical assembly of box, drive and base assures vibrationless operation, and durability.

Model "M" Bar-Nun Rotary Sifters are in daily operation in many chemical process plants. Repeat orders prove satisfaction with first installations. If you need accurate, dependable particle size separations in *your* process, be sure to send for complete information and specifications on one of these efficient sifters. Available in sizes from 2 to 76 square feet of screen surface. Write today—no obligation.

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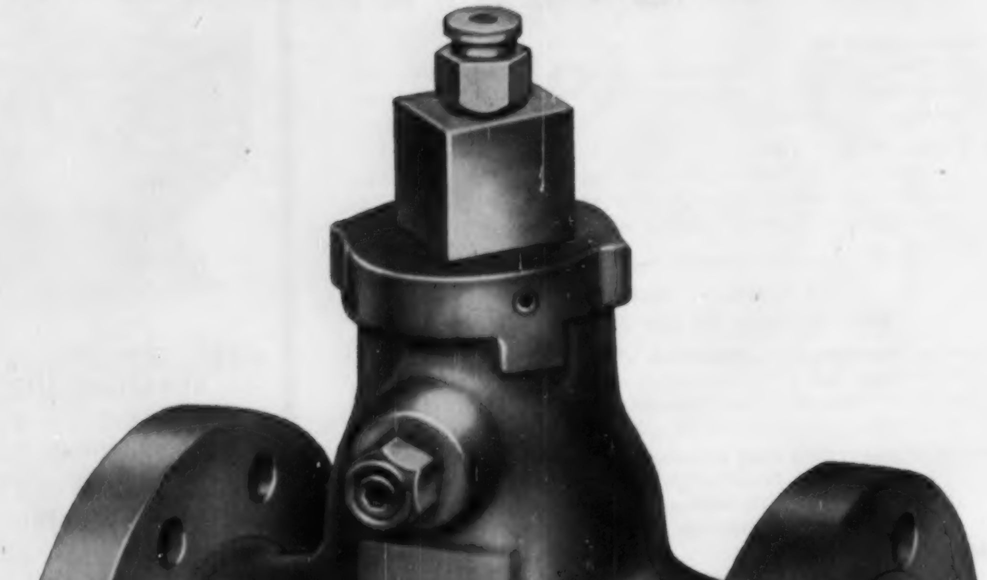
ROCKWELL-

Often Copied...



40th YEAR *of*

Nordstrom VALVES

Never Equaled

Rockwell-Nordstrom is the *original* lubricated plug valve. But that is only part of the story behind forty years of lubricated plug valve leadership. Starting with the first valve, *every major development* in lubricated plug valves has come to you *first* in a Rockwell-Nordstrom valve. Today, as always, the *oldest* lubricated plug valve is also the *newest* in terms of better performance, longer life and lower cost.

Below are listed only a few of the more than ninety basic Rockwell-Nordstrom valve and lubricant innovations. They are the reasons why Rockwell-Nordstrom valves—although often copied—have *never* been equaled. Rockwell Manufacturing Company, Pittsburgh 8, Pa.

Canadian Valve Licensee: Peacock Brothers Limited

ROCKWELL-Nordstrom VALVES

Lubricant Sealed for Positive Shut-off

ROCKWELL r

first ... for forty years *Here are just a few of more than ninety basic valve and lubricant innovations that have maintained the leadership of Rockwell-Nordstrom valves—through better performance, longer life and lower cost.*

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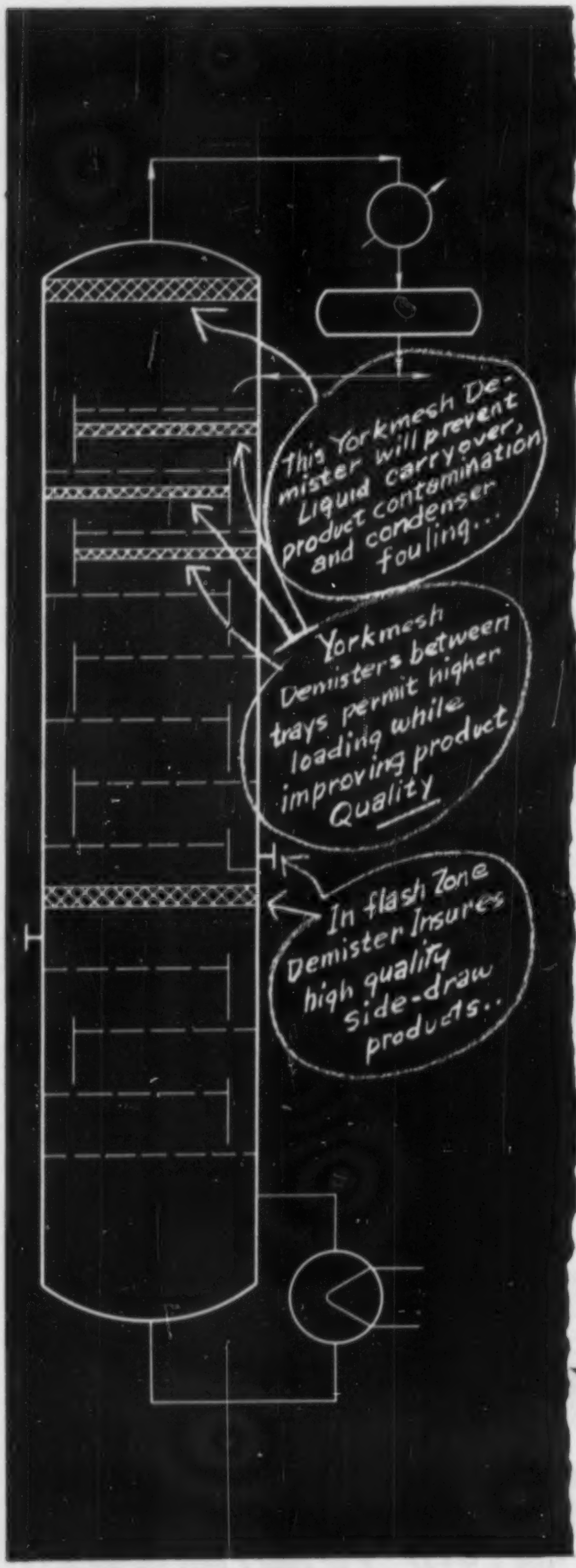
- **FIRST Venturi valve for lower cost on larger lines**
- **FIRST Lubricated plug Christmas tree valves**

*Registered trade mark Rockwell Manufacturing Company

lubricated plug valve leadership



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The advantages of positive separation of liquid from gas are obtained with negligible pressure drop.

Send details on your operating conditions and let YORK engineers take the responsibility of improving the performance of *your* equipment.

Similar improvements in process efficiency are effected by the clean separation of vapor from liquid in:

Vacuum Towers • Flash Tanks
Distillation Equipment • Evaporators
Absorbers • Scrubbers • Steam Drums

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what's in this issue

(Continued from page 3)

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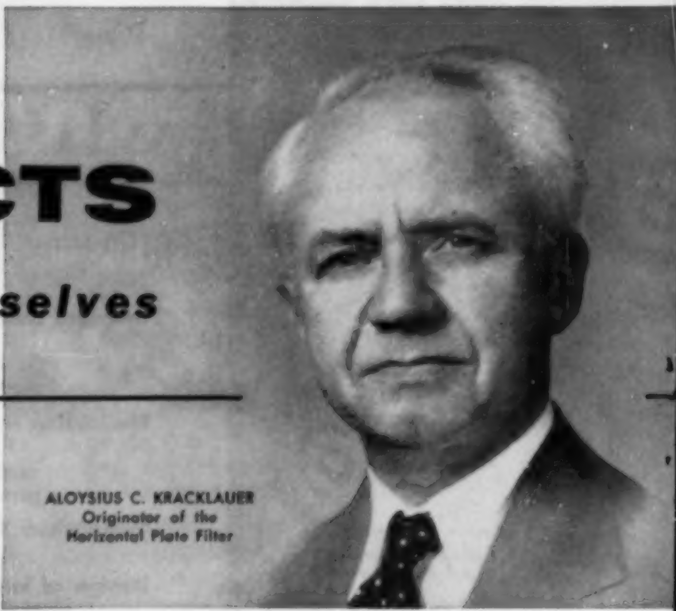
Cover design by Milton Wynne Associates

FILTER FACTS

. . . that speak for themselves

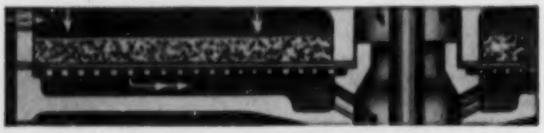


ALOYSIUS C. KRACKLAUER
Originator of the
Horizontal Plate Filter

The Sparkler original, exclusive horizontal plate design and flow principle has never been equaled for efficiency in filtering with various filter aids such as diatomite, activated carbon, activated clay, asbestos fibre, cellulose fibre, fuller's earth, etc.

1. HIGH FLOW RATE OBTAINED

Substantially higher flow rates and longer cycles are obtained with Sparkler Horizontal Plates than with filter septa in a vertical plane. Rather than being impacted into position, the filter aid is floated into position naturally and gently, making for a more uniform, interlaced, and more porous filter cake. It also enables the precoating and initial cycling to be done at lower velocity, which again results in a more sponge-like cake that permits freer flow, and ultimate longer cycle.



One glance at the cross section of a Sparkler horizontal plate and it is easy to see how such high flow is a natural result of this position of the cake. This illustration of the cross section of a plate shows the cake resting on the filter paper supported by the screen and the ample drainage space below the plate.

2. CAKE STABILITY ASSURED

When a cake is built up on a horizontal plate it rests secure without strain and maintains its original position as formed regardless of pressure fluctuation, flow rate or viscosity. Even a complete shut down of the filter will not disturb the cake. The filter can be moved about and filtering resumed at any time with complete confidence that the cake has not cracked or slipped. Only on a horizontal type of plate can this positive cake stability be maintained.

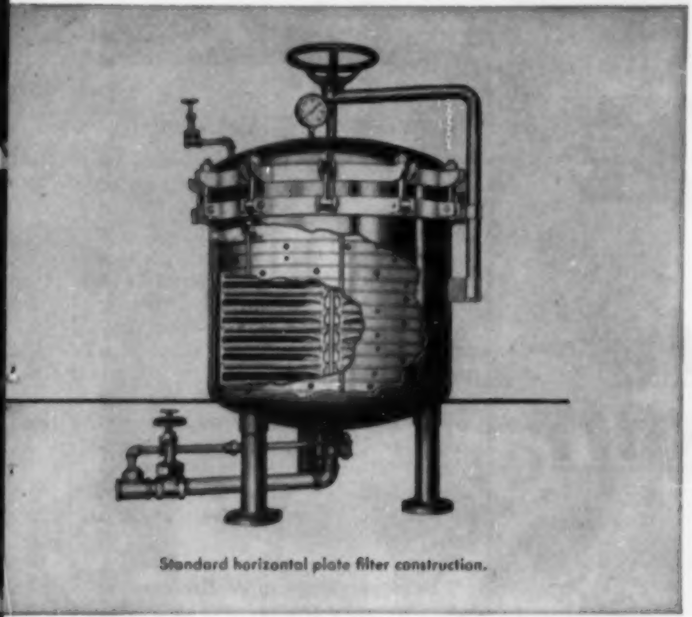
SPARKLER *horizontal plate* FILTERS

3. PRECOAT ECONOMY

It may be surprising to find how much time and filter aid can be saved in precoating horizontal plates. The use of fibrous materials (such as asbestos) to obtain cake cohesion can be completely eliminated. Floating the filter aids into position, assisted by gravity, makes for a uniform thickness of cake across the entire face of the plate, hence a thinner precoat will suffice. Add to these advantages the possibility of using a relatively dense filter paper on a Sparkler horizontal plate and you have reduced the cost and time of precoating to a very minimum.

On a vertical plate, bag, or tube, pressure is required to pre-coat, and to hold the cake during the filtering cycle. There is a tendency for the pre-coat and cake to build up thicker at the bottom with an uneven resistance to the passing of liquids. Frequently a fibrous pre-coat is required to obtain cohesion for holding the cake.

A low density even cake is built up with low pressure on a horizontal plate.

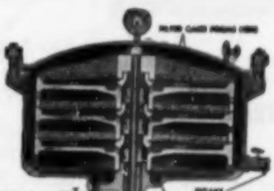


Standard horizontal plate filter construction.

4. CAKE WASHING AND DRYING

Since the cake is uniform on every plate all the way across, no channeling or by-passing is encountered in washing. Tests have shown that with a volume of wash liquid equivalent to the volume of the filter, the cake can be washed to a content of less than 1/10 of 1% of dissolved material.

Cake drying by blow-down reduces the amount of liquid held in the cake well below 15%. This compares with other types of filters where the retention may run as high as 35%. The patented scavenger plate in Sparkler Horizontal Plate Filters permits recovery of the liquid left in the filter down to almost the last drop.



Note, patented scavenger plate at bottom of the filter tank provides for recovery of practically the "last drop."

5. FREE DRAINAGE OF EFFLUENT

In the Sparkler plate design a special effort was made to reduce the flow friction of the filtrate to a very minimum. To do this, a rigid perforated metal screen is used to support the filter septum, and these perforated screen plates in turn are supported by uniformly spaced heavy raised dimples in the filter plate. This arrangement gives an unobstructed flow of the filtrate to the outlet port. A very important feature for large unit volume and for handling relatively high viscosity liquids.

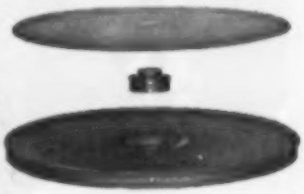
6. QUICK CHANGE CARTRIDGE

The Sparkler horizontal plates are assembled, bolted together, in a cartridge unit which can be removed and a clean dressed set of plates inserted in the filter in a matter of minutes. Thus the down time for cleaning is reduced to a negligible factor compared with filters that require a disassembly job for cleaning. A continuous flow filtration can be maintained when a battery of two or more Sparkler Horizontal Plate Filters are used as a unit due to the quick plate change feature.

A spare set of plates can be cleaned and dressed without shutting down the filter.

All Sparkler filters are completely enclosed to avoid risk of explosion in filtering volatile or flammable liquids. Filters can be jacketed at low cost for brine or gas-liquid refrigeration or for steam or high temperature heating liquids.

All stainless steel filters are available, and with the access to all surfaces of the plate for thorough cleaning, a completely sanitary filter is thus provided for food products.



Sparkler horizontal plates are easily dismantled for cleaning every inner surface making possible complete sanitation.

Other structural metals include nickel, mild steel, Hastelloy, monel and bronze.

Sparkler Horizontal Plate Filters are widely used for chemicals, foods, pharmaceuticals, beverages, beer, whisky, oils, petroleum derivatives, plating solutions, and many other products. Available in capacities up to 200 sq. ft. of filtering surface. Multiple units recommended for larger requirements. All sizes can be portable.

Write Eric Anderson—our filtration engineering service is available to help solve your filtration problems.

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MUNDELEIN, ILLINOIS

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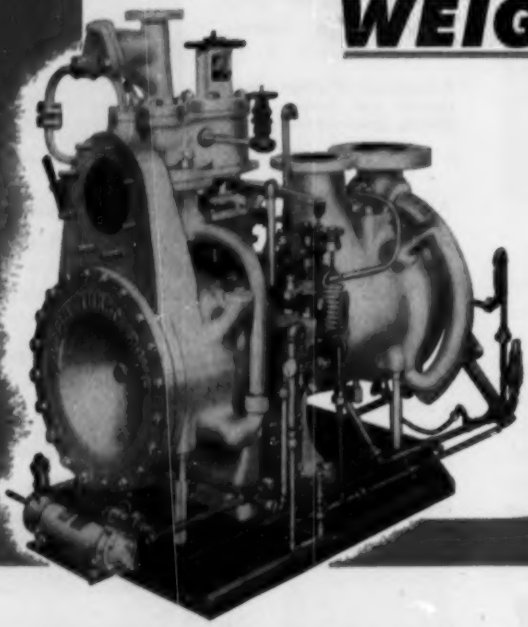
Representatives in principal cities throughout the world.

SPARKLER *horizontal plate* FILTERS

SPARKLER HORIZONTAL PLATE FILTER

SAVE
SPACE
STEAM
WEIGHT



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THE J. S. COFFIN JR., COMPANY

TURBO PUMPS

Englewood, New Jersey

Letters to the editor

Big "Yes" on Orientation Film

I am very much interested in the idea expressed by Charles E. Dryden in the March issue of C.E.P. (Letters to the Editor, p. 14). While I am not in a position to commit [my company] to a contribution toward preparation of a film describing chemical engineering work, I know that I could sell our management on contributing to such a worthy cause.

I think you people ought to get some estimates and draft a proposal for consideration by companies that have expressed interest, or that have a reputation for being progressive in these areas.

Here's hoping you receive many letters.

Director,
Employee Training & Development

Birthday Arithmetic

. . . My picture posed with Mr. Adams of Freeport, Texas, is very good (Los Angeles Meeting pictures, C.E.P. March, p. 94)—except that I imagine some of the "old timers" will wonder "how come" if I was 30 years old in 1908 I could claim to be 74 in 1956.

We had to be 30 years old to meet the age requirements to become active members and I was 31, being born in 1877, so a week ago I celebrated my 79th birthday.

John G. Dean
Los Angeles, California

The "O.R. Attitude"

Congratulations on your comments under the heading "The O. R. Attitude" on the "Opinion and Comment" page of your March issue.

There are still a great many problems in development work which can be worked out in the Acheson manner and our big research laboratories, with all their expensive equipment and team play, must still remember that a negative result is no better than the men who contributed to it.

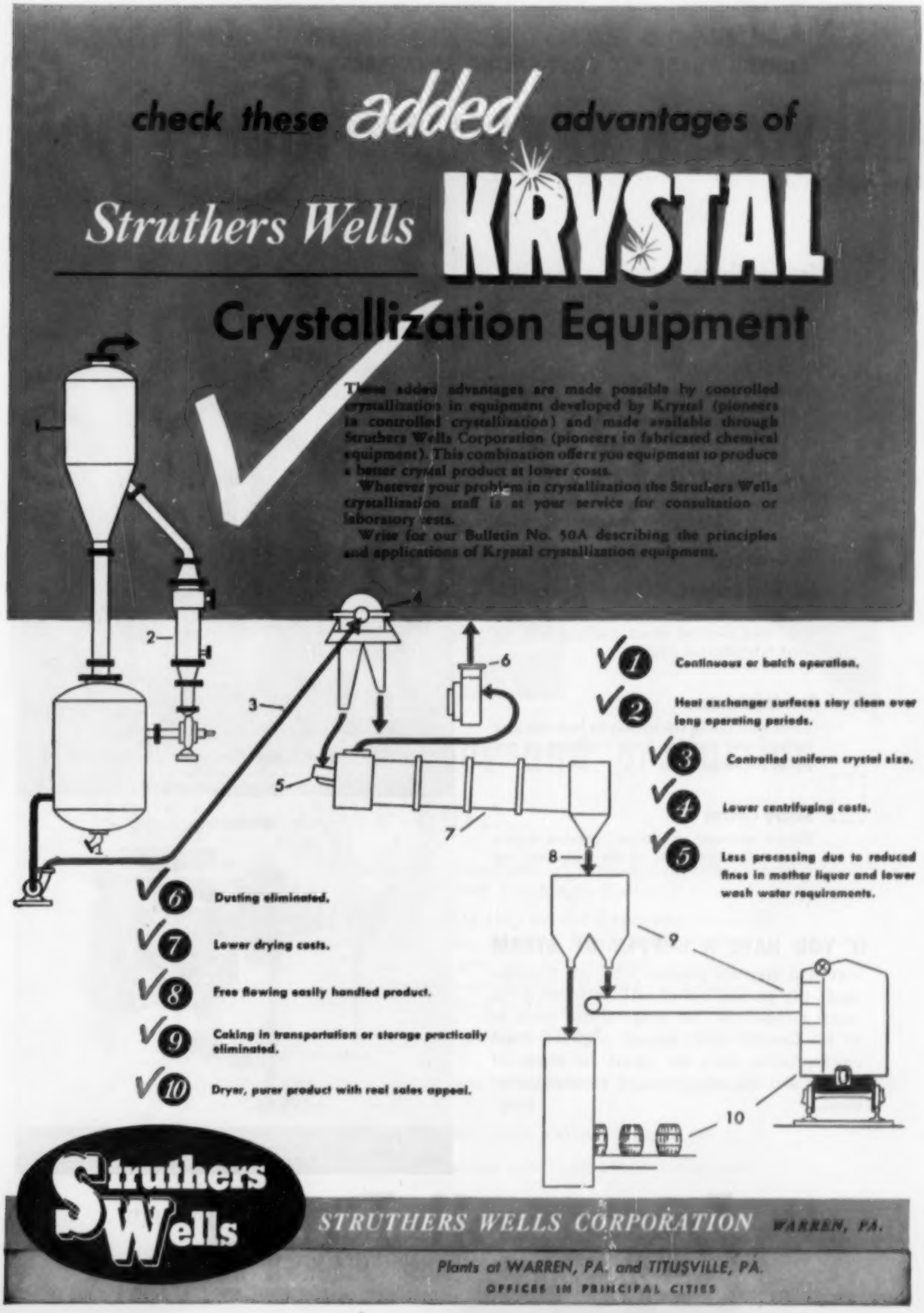
H. Leslie Bullock
New York, New York

Progress with Progress

I just wanted you to know how pleased we were with the layout and editing on our article "Design of Light Hydrocarbon Cracking Units" appearing in the March 1956 issue . . .

I continue to be impressed each month by the fine job you are doing with

(*Continued on page* 16)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1 Continuous or batch operation.
2 Heat exchanger surfaces stay clean over long operating periods.
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No special foundations or vibration-isolating devices are necessary.

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Cooling is obtained simply by the action of steam and water. There are no moving parts to wear out — no shut-downs for repairs.

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Peak overloads are easily met without any danger of straining or damaging the equipment.

Low-Cost Operation

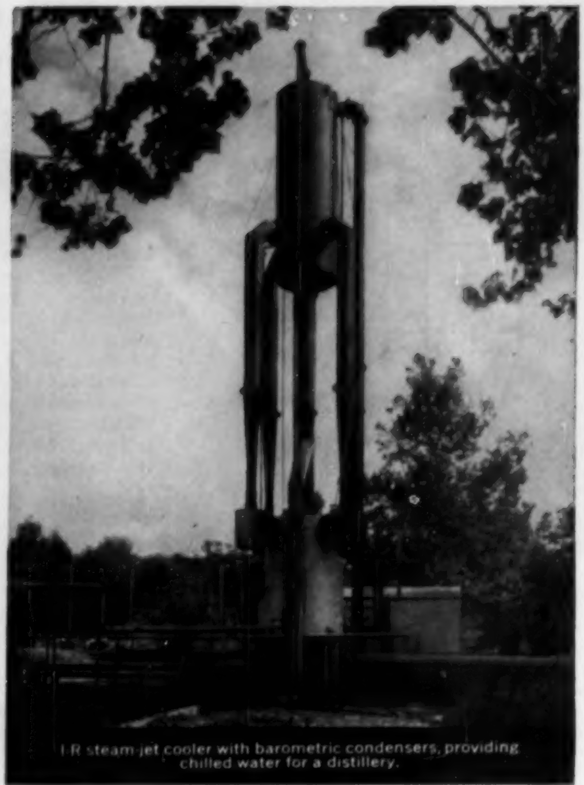
Refrigerant is water — cheap, safe, dependable. And low-cost steam that's already on hand furnishes the power.

Low Maintenance

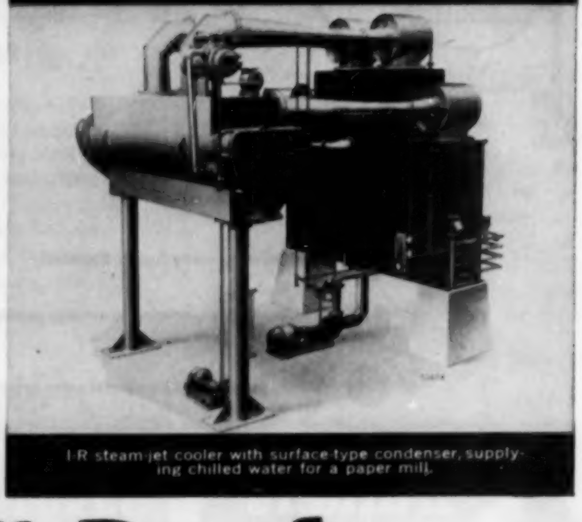
There's no costly refrigerant to leak out and replace — no wearing parts — nothing to get out of adjustment.

Simple Control

Simple manual or remote operated valves control the operation of the entire cooling system.



I-R steam-jet cooler with barometric condensers, providing chilled water for a distillery.



I-R steam-jet cooler with surface-type condenser, supplying chilled water for a paper mill.

IF YOU HAVE A SUPPLY OF STEAM

— even at very low pressure — be sure to investigate the possibilities of safe, low-cost *water vapor refrigeration* for temperatures down to 35°F. Consult your nearest Ingersoll-Rand representative. He's an expert on steam-jet cooling and the application of vacuum equipment. 13-113

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Then, compare K&M valves in service . . . *side by side* with any other diaphragm control valve.

Keep your own maintenance records . . . and your own records will tell the K&M story.

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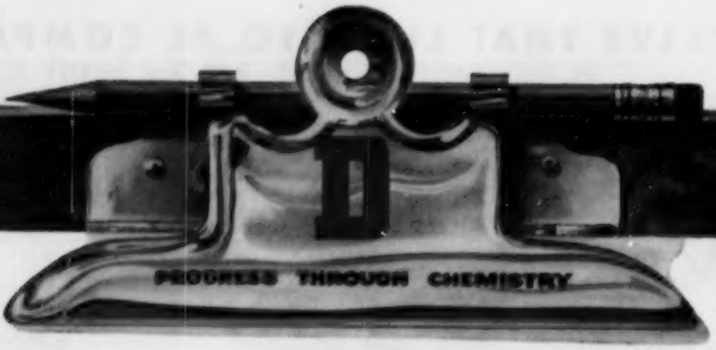


Announcing Expanded Rare Earths and Thorium program

of Davison Chemical and Rare Earths, Inc.

Davison Chemical Company, Division of W. R. Grace & Co., and Rare Earths, Inc., Pompton Plains, N. J., a wholly-owned subsidiary of Grace, have joined in a program of expanded production, sales, research and development of thorium, cerium and other rare earths compounds.

Rare Earths, Inc., organized in 1947 for the production of Rareox, an optical quality cerium oxide polishing powder, has diversified into thorium, cerium and other rare earth chemicals. Now, additional facilities are being installed at Davison's Curtis Bay (Baltimore) plant. This means added service plus intensified research and development.

Current applications, in addition to thorium as a potential source of atomic energy, are glass polishing, glass coloring and decolorizing, as a component in carbon arc electrodes, in lighter flints, and for ferrous and non-ferrous metallurgical alloys.

Rare Earths, Inc., an affiliate of Davison Chemical Company, Division of W. R. Grace & Co., offer a quality line of thorium and rare earth chemicals. Contact your Davison Sales Office for additional information on these interesting and useful products.

DAVISON CHEMICAL COMPANY

Division of W. R. Grace & Co.

Baltimore 3, Maryland

Sales Offices: Baltimore, Md.; Chicago, Ill.; Columbus, Ohio; Houston, Texas; New York, N. Y.

Producers of: Catalysts, Inorganic Acids, Superphosphates, Triple Superphosphates, Phosphate Rock, Silica Gels, Silicofluorides. Sole producers of DAVCO® Granulated Fertilizer.

NO STUFFING BOX

POSITIVE DISPLACEMENT

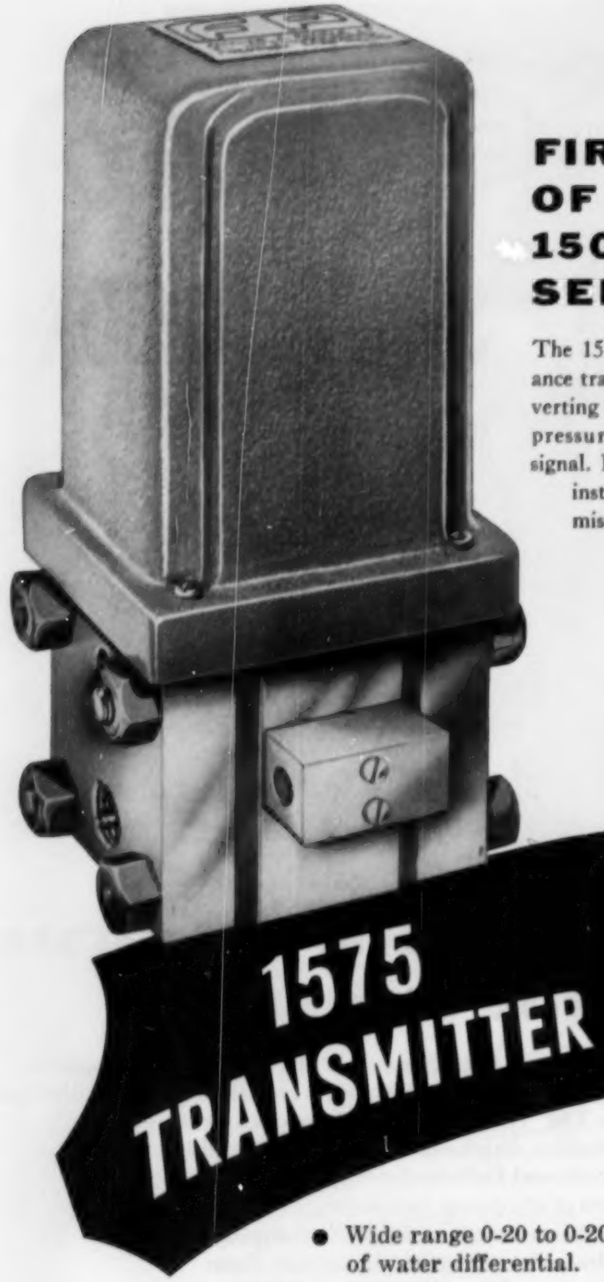
Specify Lapp Auto-pneumatic PULSAFEEDER

. . . for Automatically Controlled Metering of Liquids

The outstanding features of the Lapp "Auto-Pneumatic" Pulsafeeder make possible continuous automatic processing of liquids which cannot be satisfactorily handled by plunger-type metering pumps. The "Auto-Pneumatic" Pulsafeeder is a piston-diaphragm pump providing positive displacement without the problems of a stuffing box. A hydraulically balanced Pulsafeeder diaphragm isolates the product from the working parts of the pump, preventing product leakage or contamination. With pneumatic instrument control, the pumping rate of the "Auto-Pneumatic" Pulsafeeder automatically adjusts from zero to full capacity. Manually adjustable models also available.

WRITE FOR BULLETIN 440 *with typical applications, flow charts, description and specifications of models of various capacities and constructions. Inquiry Data Sheet included from which we can make specific engineering recommendation for your processing requirement. Write Lapp Insulator Co., Inc., Process Equipment Division, 688 Wilson Street, Le Roy, New York.*

Lapp



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- Wide range 0-20 to 0-200 inches of water differential.
- Adjustable hydraulic damping.
- All working parts sealed from process fluid.
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- Quickly removable without disturbing piping.

Write for complete information. Ask for catalog 50-30.

FP FISCHER & PORTER CO.

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Letters to the editor

(Continued from page 10)

C.E.P. There is no reason why a technical magazine should not have an attractive cover and arrangement. You certainly are proving that this is possible.

Howard F. Rase
Austin, Texas

Wisconsin Process Economics

The author of the paper "Wisconsin Process Pebble Furnace Fixes Atmospheric Nitrogen," C.E.P., April, 1956, has kindly consented to providing the following discussion of the comparative economics of the process:

Fuel usage in the Wisconsin Process furnace amounted to 14,000,000 B.t.u./ton of equivalent 100% nitric acid, which is equivalent to 63,000,000 B.t.u./ton of N_2. The electric arc furnace used approximately 59,000 KWH/ton of N_2 or 200,000,000 B.t.u./ton of N_2; thus the Wisconsin Process utilized about one third the energy of the old Birkeland-Eyde Process or modifications thereof.

The capital cost of the Wisconsin Process furnace, including auxiliaries, is approximately $300/annual ton of N_2 compared with the Birkeland-Eyde furnace cost of $700/annual ton (1911 cost), including power generating equipment. The cost of the Wisconsin Process furnace is based on the semi-commercial plant installed at the Sunflower Ordnance Works. Larger plants would reduce the capital costs considerably.

With respect to the present ammonia-ammonia oxidation plants to produce nitric acid, the Wisconsin Process is not quite competitive, based on the silica gel recovery system utilized at Sunflower. Before World War II, it appeared that the Wisconsin Process could compete, but the rapid technological advance of the ammonia and ammonia oxidation processes resulted in lower operating and capital costs despite inflation. Approximately 60% of the costs, operating and capital, of the Wisconsin Process are incurred in the recovery system, which is based upon fluidized silica gel. Work is continuing on other recovery systems as well as improvement of the high temperature furnace.

There are indications that the Wisconsin Process, as is, may be able to compete with the conventional processes with respect to production of N_2O_4 should markets develop in the future.

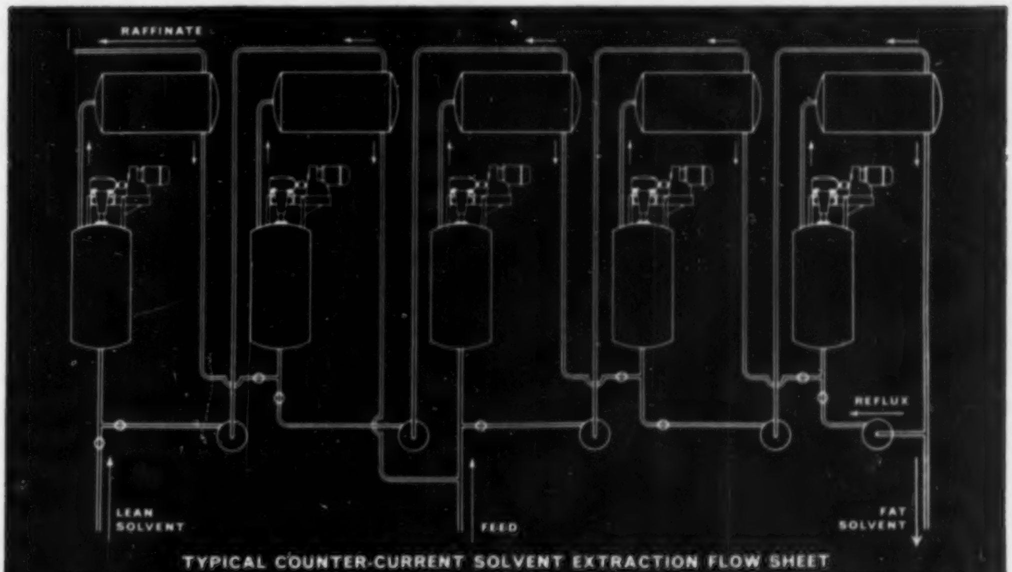
E. D. Ermenc
New York, New York

(Noted and Quoted on page 18)

Turbo-Topics

TURBO-MIXER GENERAL AMERICAN TRADE MARK

TURBO-MIXER, a division of
GENERAL AMERICAN TRANSPORTATION CORPORATION



TYPICAL COUNTER-CURRENT SOLVENT EXTRACTION FLOW SHEET

maximum solvent extraction efficiency with TURBO on the job

Here's another petrochemical operation where continuous Turbo-Treaters have served successfully. Most presently installed systems for CAA extraction of BUTADIENE depend on staged Turbo impeller and stator ring design for maximum extraction efficiency.

Turbo engineers have years of experience in the design of continuous mixers for extraction, blending and spent solvent recovery. Turbo's built-in ruggedness provides 24-hour heavy-duty service—assures you of "headache free" production and lower costs in the long run.

SALES OFFICE: 380 MADISON AVENUE, NEW YORK 17, NEW YORK
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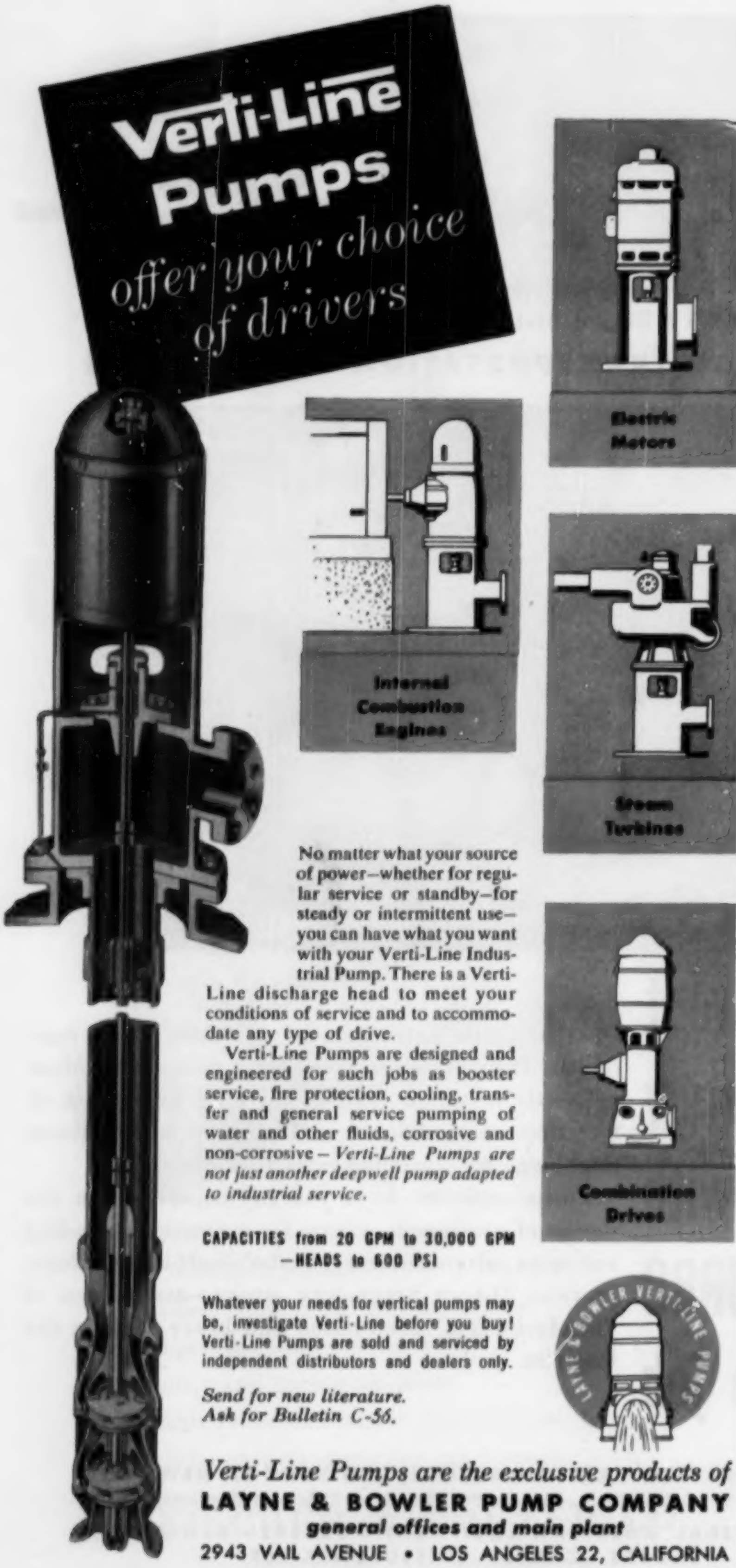
OTHER GENERAL AMERICAN EQUIPMENT:—DRYERS • DEWATERERS TOWERS • TANKS • PRESSURE VESSELS



Noted and quoted

Blazing New Trails

Unfortunately, as we become more and more dependent upon team performance, it becomes increasingly difficult to isolate and recognize individual accomplishment. Because we are faced with complexities and challenges which often are too sweeping for personal solution, the importance and significance of the individual is very likely to be minimized. In the field of science, in the field of business, in the field of politics, and in the military, we see emphasis placed on the theory that the individual exists only as a member of a group and that he is valuable and effective only as he works well with others.

The raw stuff of all progress is people. No matter how well organized or how technically sophisticated we become, the fact is that progress originates in creative thought, a purely personal attribute—just as characteristic of the worker on the machine as it is of the scientist in the laboratory, or the writer in his study.

The great advances in science and in thought have come about through the efforts of people—people who perhaps struggled against the restrictions of environment, and who had the vigor, imagination, and initiative to question traditional patterns of thought. We have progress only when some individual, distrustful and impatient with existing concepts, blazes a new trail into the unknown, or has a dream and the individual initiative to make it come alive so that others may see.

C. H. Greenewalt
"Individual Responsibility"
before National Safety Council

Collective Bargaining and The Individual Engineer

. . . We need to consider what courses of action we might take in dealing with this problem. [Unionization of Engineers].

First, the schools and colleges. They must somehow instill in the young engineer the conviction that he is a professional and that he and his profession will progress only in proportion to the exercise of his own abilities and efforts. He must understand that his own inner resources will take him most rapidly and profitably along the road he wants to go. I am not so sure that as a layman I know how this can be accomplished, but if engineering is to become a highly accepted profession, those who practice it must learn the meaning and ethical responsibilities of professionalism.

(*Continued on page* 24)

WHY PAINT PIPELINES

when Plicoflex does 2 jobs in 1!

Built-In Color Coding Plus Lasting Corrosion Protection

Plicoflex No. 340 is a laminated tape whose primary job is protecting pipelines against corrosion. Available in black, white and six brilliant colors, it can do an *extra* job for you – eliminate frequent costly painting of lines for color-coding purposes – at very low cost. And the color is in the tape ... uniform in thickness ... far outlasts any paint job!

That's one bonus. Now look at some of the others:

Highest Shock-Impact Resistance ... Made of tough polyvinyl chloride film laminated to butyl rubber, Plicoflex No. 340 Tape offers rugged extra heavy thickness together with ample resiliency to resist damage from accidental blows.

No Moisture Migration ... The engineered cold-flow properties of Plicoflex compounded butyl rubber fill irregularities on pipe, provide a perfect seal at the overlap.

Stronger, Permanent Bond ... Solid non-volatile film that will not support combustion and provides a permanent colored coating which will not chip or flake. Quickly forms an *inseparable* bond to the pipe.

Low Cost ... Plicoflex job-site application methods cut coating manpower requirements to a minimum; and in most cases cost less to apply than other coatings.

Want more? Write, wire or phone

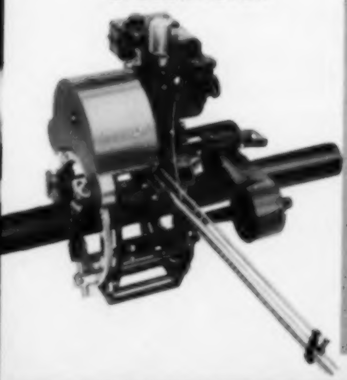
PLICOFLEX
TRADE MARK

PLICOFLEX, INC.

1566 EAST SLAUSON AVENUE • LOS ANGELES 11, CALIF. • LOGAN 8-4335

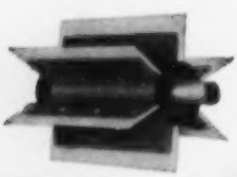
Teletype No. LA 180

You can hand-wrap Plicoflex ... or turn the job over to this new lightweight wrapping machine, the Plicoflex SPEEDMASTER

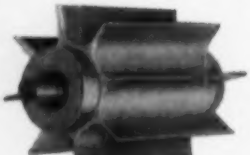


LOCKS Air and Gas in

–FEEDS Materials out!



6-VANE ROTOR
with plastic, rubber, or other replaceable vanes.



12-VANE ROTOR
designed for use as a feeder, furnished with carbon steel cylinder and brass blades. Other metals available.

SOLID 8-VANE ROTOR
furnished in cast iron, bronze, stainless steel, monel, etc.

The MIKRO Rotary Airlock provides an ideal method of feeding free-flowing materials under pressure or vacuum, while sealing in air or gas from passing on with the material.

A precision-built rotary valve, the MIKRO Airlock continuously feeds materials from an upper chamber into a lower one by gravity. The vanes of its rotor provide a seal which prevents leakage of air or gas from the upper chamber into the lower chamber, or into the atmosphere.

Applications of the MIKRO Rotary Airlock are many and extremely varied. It can be used at the discharge of a pulverizer or a dust collector. It can also be used on the discharge of a blender or mixer to regulate the flow of material from the unit. It can likewise be used as a feeder to control the rate of flow from a storage bin or hopper, or as a feeding mechanism to a pulverizer, a pneumatic conveying system, mixer or blender.

The MIKRO Airlock is available for low or high pressure use, with capacities varying from 100 to 15,000 lbs. per hour depending upon rotor speed and density of material handled. Furnished with various types of rotors and vanes to meet specific requirements.

SEND FOR new MIKRO Rotary Airlock Bulletin

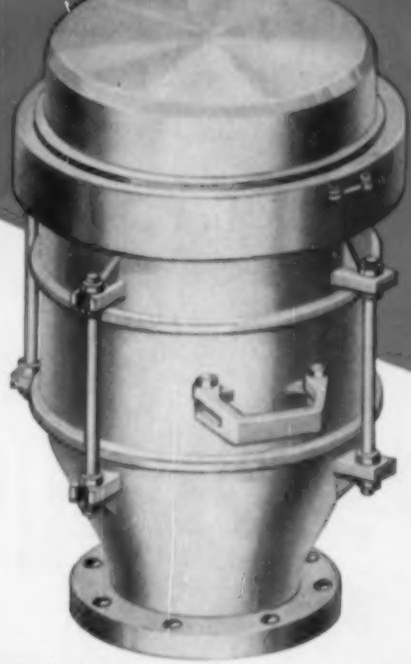
Mikro-D

PULVERIZING MACHINERY DIVISION
METALS DISINTEGRATING COMPANY, INC.
31 CHATHAM ROAD — SUMMIT, NEW JERSEY

PULVERIZING • AIR CONVEYING • DUST COLLECTING EQUIPMENT

Introducing...

A New Lightweight BS&B Tank Vent And Flame Arrestor*



FEATURES

1 High Capacity

... high capacity pressure and vacuum relief comparable to the flow of an open nozzle.

2 Vapor-Tight

... one seal only — flexible, positive, replaceable.

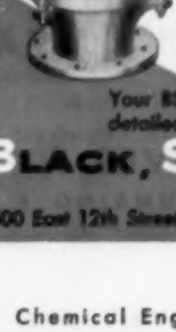
3 Rugged with Lightweight Construction

... superior design and use of quality materials have resulted in a lighter weight vent.

* PATENT PENDING

The BS&B Type 76-17 Arrestor Vent is a combination vent and cartridge type flame arrestor to prevent the spread of an external flame into the storage tank while venting. The topworks is identical to the Type 76-16 vent (described below), with a modified base to fit the top of the flame arrestor. Clamping edges are interchangeable to allow continued operation of the vent when the arrestor section is removed. Arrestor vents are available in sizes 4" through 12" and mount to ASA boltipg circles. Pressure and vacuum settings start at ½ ounce per square inch.

The BS&B Type 76-16 Tank Vent is a lightweight venting device for atmospheric storage tanks containing volatile fluids, and features a floating seal which provides positive shut-off under both pressure and vacuum. This seal consists of two flexible diaphragms which contact valve seats. Easy access is provided to it by a quick-opening V-clamp which holds the cover in place. These vents mount to ASA bolting circles in sizes 4" through 12". Pressure and vacuum settings start at ½ ounce per sq. in.



The BS&B Type 76-18 In-Line Arrestor is for a free vent system, requiring a flame arrestor to protect vent lines on process vessels when the emitted vapors are explosive or ignitible. End flanges are 150 lb. ASA in sizes 4" through 12".

Your BS&B Representative will be glad to give you detailed information. Or you may write to . . .

BLACK, SIVALLS & BRYSON, INC.

Controls Division, Dept. 2-DX5

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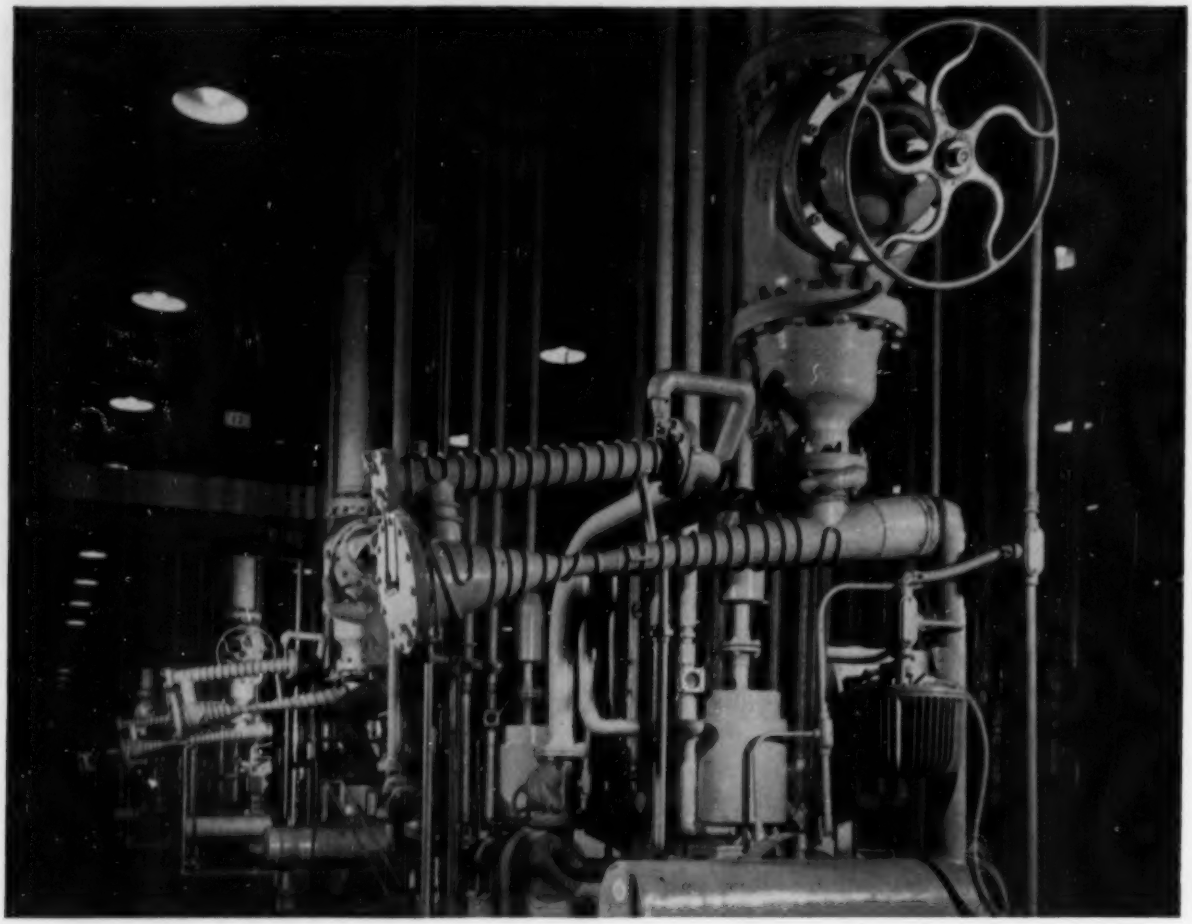
Kansas City 26, Missouri



These Crane valves holding 25 microns absolute pressure after 2 years on vacuum service

The Case History—Valves frequently are the most critical points in a vacuum system. But that's not the case with this large Southern light metals refiner.

This plant reports no trouble or expense over a 2-year period in maintaining a vacuum of less than 25 microns absolute for its distillation process.

The tight-holding valves installed about 2 years ago on the lines from vacuum pumps shown above are Crane No. 1611 diaphragm pattern. These 12-in. packless iron body valves are used about once daily.

They've allowed no in-leakage at the seat, bonnet-joint, or through the diaphragm. No maintenance whatever has been given the valves since installed. They operate easily and look good for such service indefinitely.

This high efficiency performance is mainly due to Crane separate disc and diaphragm design. The diaphragm used as a bonnet seal only is not subject to destructive crushing. Conventional type disc and body seat provide a metal-to-Neoprene seating that's ideal for vacuum and hard-to-hold fluids.

Moderately priced, Crane diaphragm valves deserve your consideration for many ordinary services, as well as sludges, slurries and corrosive fluids. They are made in a wide variety of body and trim materials, in ½ to 12 in. sizes.

Ask your local Crane Representative about them, or write to address below for literature.

CRANE VALVES & FITTINGS

PIPE • KITCHENS • PLUMBING • HEATING

Since 1855—Crane Co., General Offices: Chicago 5—Local Service Everywhere Through Branches & Wholesalers

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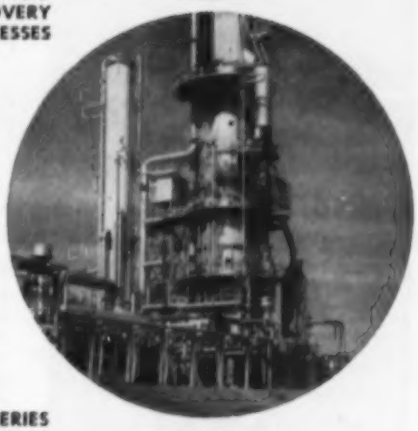
• FERTILIZER PLANTS, LIQUID or DRY PROCESS

• SOLVENT EXTRACTION, FAT SPLITTING, FATTY ACID and GLYCERINE RECOVERY PROCESSES



• PETROLEUM REFINERIES or SINGLE UNITS

• FEED PLANTS and STORAGE FACILITIES

Blaw-Knox engineers have long experience in the design, engineering, procurement, construction and initial operation of all types of process plants. This experience is available for new additions to existing operations, as well as for remodeling and modernizing older units. Why not consult Blaw-Knox engineers on your plans for expansion of facilities, broadening of markets, or revamping of obsolete plant and equipment?

BLAW-KNOX

BLAW-KNOX COMPANY

Chemical Plants Division

Chicago 1, Illinois / Pittsburgh 30, Pa.

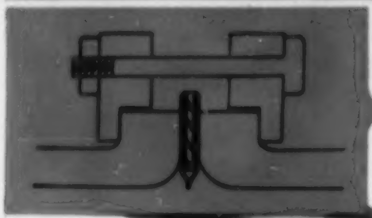
Birmingham, New York, Philadelphia, San Francisco, Washington, D.C.

complete plants, large or small, or a single unit

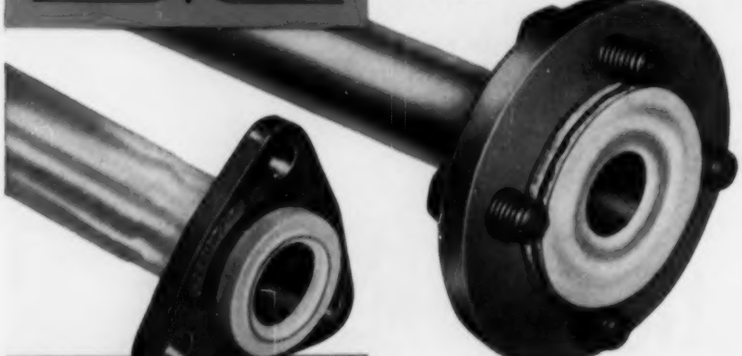
CHEMISEAL GASKETS

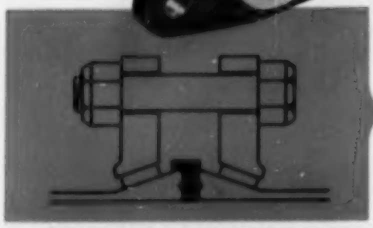
made of du Pont TEFLON

and accessories for chemical piping



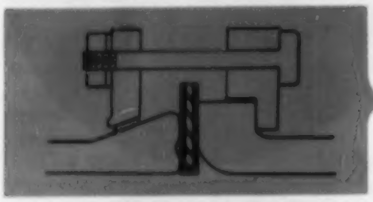
Chemiseal Jacketed Gasket, Type 1-339 WA. Compressed asbestos sandwiched between woven asbestos and enclosed in a Teflon envelope. Ideal for glass-lined steel connection. Catalog No. TG-953.



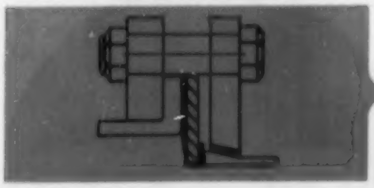


Chemiseal Snap-on Type 820 Gaskets. Molded to match contour of conical-end glass pipe, they assure perfect automatic centering of joints and free flow of medium. Made for all standard pipe sizes from ¼ in. to 6 in. Catalog No. TG-953.

Chemiseal Expansion Joints, No. 212, and Flexible Couplings, No. 202, absorb shock and vibration, thermal expansion and contraction. Correct misalignment. Connect unlike piping ends and nozzles. Catalog No. EJ-1155.



Chemiseal Adaptors No. 2-CRS, provide a tight, safe seal between unlike piping ends and nozzles. A steel bearing ring provides rigidity. Resilient core assures safe seal at low bolt loads. Teflon Jacket protects and contains easy-to-handle single unit. Catalog No. TG-953.



Chemiseal Reducers No. 3-CRS are one piece assemblies similar to type 2-CRS, but designed to connect unlike pipe sizes with minimum length requirements. Standard sizes from 1 in. to 6 in. Bulletin No. 3-CRS.

Ask your U.S. Gasket—Belmont Packing Distributor or write for literature.

UGS BELMONT

UNITED STATES GASKET CO.
Camden 1, New Jersey

U.S. GASKET · BELMONT PACKING

Noted and quoted

(*Continued from page* 18)

Furthermore, the schools and colleges may defeat their very purpose when they advise or condone the better man's refusing employment with a company solely because its engineers are in a collective bargaining unit. It is only by having the better engineers meet this challenge and lend their influence in such groups that the question can be satisfactorily resolved. To isolate them may result in permanent division of engineers into two opposing camps.

Second, the Technical Societies. The technical societies must look beneath the surface of the collective bargaining question in order to understand it and meet it. This will take patience and understanding. The problem can be evaluated and solved only in a calm and tolerant atmosphere. It is a problem already overcharged with emotionalism. The societies do need to be more vigorous in finding the key to some unification or integration in professional affairs. On the other hand, to try to meet the problem of unionization by becoming collective bargaining agencies themselves would be fatal. They would inevitably then find themselves moving in the direction of the typical labor union behavior and practices.

Third, industry. Industry has a serious challenge to understand and practice its part in the professional relationships with its engineers. Under the law, if its engineers elect to bargain collectively it must do so in good faith. On the other hand, it must at the same time make certain that the collective bargaining does not destroy, any more than can possibly be avoided, the maintenance of that freedom of individual acomplishment and of inter-communication that is essential to the attainment of the best professional results.

Finally, the engineer himself. Whether or not engineering advances as a profession or whether collective bargaining or the individual relationship is to be characteristic of the engineer in industry rests almost entirely with the individual engineer himself. The most any of the rest of us can do is to encourage him to take a sincere interest in this important subject, to create an atmosphere conducive to his proper consideration of it and to supply him as completely and objectively as we can with the views, experience, and data we may have on it. Engineering ethics, from the viewpoint of industry, will rise or fall on the decisions of the engineer himself.

Gerry E. Morse
Speech before A.S.E.E.

(*Continued on page* 32)

S/Kapades in industry

THE CASE OF THE PERIODIC PUMPING PROBLEM AND THE PATIENT PLANT ENGINEER

" . . . ub glub bedubtub
(this situation's becoming impossible)," glubbled Barney, the patient plant engineer.

"Ub tub ud ub tub ud ub tub
(I've tried and I've tried and I've tried)," bubbled Shorty, his faithful, conscientious assistant,
"Bud dub pubs wud hubtub dub slubb
(But the pumps won't handle the sludge)—it ruins them every time."

"Wub, subtub's *gub* tub bub dub
(Well, something's *got* to be done)," answered Barney. "Or, *I'll* lose my *patience* AND YOU'LL LOSE . . . well, you'll be an *ex-faithful, ex-conscientious* assistant plant engineer."

With that, Shorty stubbled away . . . in the direction of his office and catalog files.

"I've got it," shouted Barney. "It says either an SK Jet Eductor or Syphon is good for pumping liquids where solids or semi-solids must pass through the apparatus and is ideal for use where pumping is periodic."

So he called in his nearest SK Sales Engineer who made an on-the-spot survey of the situation and, because of certain special considerations, recommended the use of an SK Fig. 264 Water Jet Eductor.

PATIENCE REWARDED

It paid to be patient. Now, the recurring drainage problem has been solved, simply and inexpensively. The SK Fig. 264 Water Jet Eductor uses pressure liquid, entering the eductor through a nozzle, to create a vacuum in the line which causes the suction liquid to flow up into the body of the eductor where it is entrained and discharged. Solids and semi-solids present no problem. Since there are no moving parts and the eductor is self-priming, the jet is ready to operate when required.

MORAL:

Get acquainted with all types of SK Jet Apparatus. Send for a copy of Condensed Bulletin J-1. Make use of a qualified specialist, your nearest SK Sales Engineer.

Schutte and Koerting COMPANY
MANUFACTURING ENGINEERS

2245 STATE ROAD, CORNWELLS HEIGHTS, BUCKS COUNTY, PA.

JET APPARATUS: Ask for Condensed Bulletin J-1.
ROTAMETERS & FLOW INDICATORS: Ask for Condensed Bulletin 18-RA.
VALVES: Ask for Condensed Bulletin V-1.
HEAT TRANSFER APPARATUS: Ask for Condensed Bulletin HT-1.
GEAR PUMPS: Ask for Bulletin 17-A.

Cement Manufacturers and Chemical Lime Manufacturers

There is a deposit of over 100 million tons of limestone strategically located on the Norfolk and Western — with a known thickness of more than 100 feet, and an average $CaCO_3$ (Calcium Carbonate) analysis of over 97.5 per cent.

And here are typical analyses *

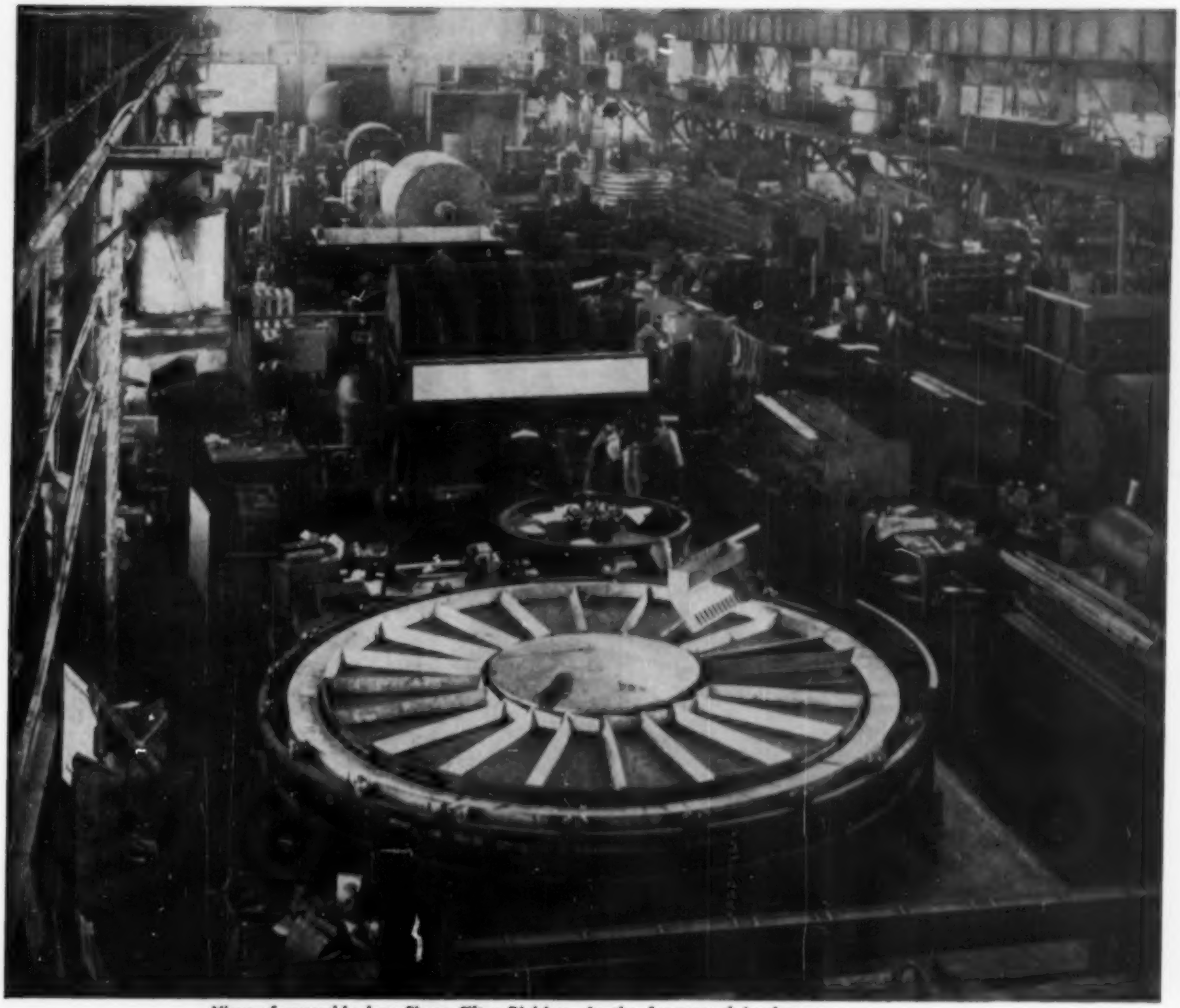
	DHL-1-1	DHL-1-2	DHL-1-3
SILICA (SiO_2)	.36%	.30%	.34%
IRON OXIDE (Fe_2O_3)	.072	.043	.049
ALUMINA (Al_2O_3)	.21	.20	.19
LIME (CaO)	55.00	54.90	55.40
MAGNESIA (MgO)	.65	.62	.51
SULPHUR (S)	.012	.011	.015
PHOSPHORUS (P)	.006	.006	.009
IGNITION LOSS	43.20	43.50	43.20
CALCIUM CARBONATE (Calculated)	97.90	97.72	98.51
MAGNESIUM CARBONATE (Calculated)	1.36	1.30	1.07

* Report prepared by Pittsburgh Testing Laboratories, Pittsburgh, Pa.

If you're planning a plant — it will pay you to see us. Call or write; we will respect your confidence. We would like to tell you about this valuable limestone deposit.

INDUSTRIAL AND AGRICULTURAL DEPT.
Drawer CP-710 (Phone 4-1451, Ext. 474)
Norfolk and Western Railway
ROANOKE, VIRGINIA

Norfolk and Western RAILWAY



View of assembly bay Eimco Filter Division. In the foreground is shown 120 sq. ft. pan filter, all stainless steel construction for phosphoric acid.

SPECIFY EIMCO FILTERS FOR GUARANTEED PERFOMANCE

Eimco filters are built to meet the exacting requirements of process engineers all over the world.

The wide range in types of filters available at EIMCO include both vacuum and pressure designs in: Drums, Discs, Agidiscs, Top Feed, Dewaterers and Dryers, Pans, Tubular elements and Plate and frames. Each of these designs is available with numerous attachments for cake dewatering and cake removal. Materials of construction are selected with regard to the material to be filtered.

Every filter job receives individual attention at Eimco. The Eimco filter delivered in your plant provides you with the finest filtration equipment you can buy at any price and with a machine guaranteed to perform on your product.

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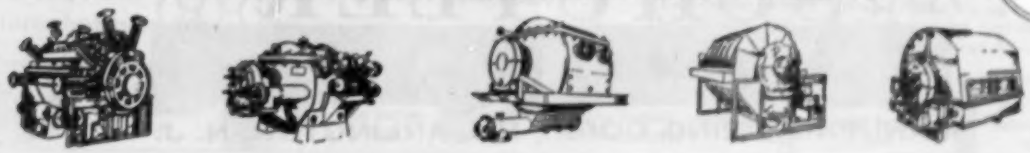

B-175

get cleaner more economical liquid/vapor

SEPARATION

with "Schuylernit" Entrainment Separators

Stop costly liquid loss . . . in chemical and petroleum process equipment at lower cost with "Schuylernit" Entrainment Separators (mist eliminators). Specifically designed and constructed to separate liquid and small solid particles from any gas or vapor, "Schuylernit" Entrainment Separators assure these advantages: Elimination of liquid loss . . . increased throughput . . . improved process efficiency . . . reduced vessel sizes . . . reduced contamination . . . improved product quality.

- **"Schuylernit" Entrainment Separators are highly recommended for:** Vacuum and flash towers, gas absorbers, evaporators, distillation equipment, knock-out drums, steam drums, scrubbers, gas filters, compressors.

Immediate delivery on round, square or special shapes in any thickness for new or existing equipment. Send for illustrated Bulletin 203, Schuyler Manufacturing Corp., 81 Porete Avenue, North Arlington, New Jersey.

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specialists in liquid/vapor separation

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Here's Why It Pays To Start With

"Karbate" Impervious Graphite Process Equipment — And Contnues To Pay While You Use It:

Low First Cost: Prices of standard, quantity-produced "Karbate" Process Equipment compare favorably with those of other materials less resistant to corrosion. Delivery is quick — generally from stock.

Long Service Life: Unequalled corrosion-resistance, immunity to thermal shock and ruggedness of mechanical design keep "Karbate" Process Equipment on the job with minimum maintenance.

No other material of construction combines the advantages listed above with such other desirable properties as high thermal conductivity, freedom from metallic contamination, ease of fabrication and modification in the field, plus a ***complete technical advisory service.*** Literature furnished promptly on request.

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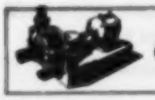
Pumps— Catalog Section S-7250


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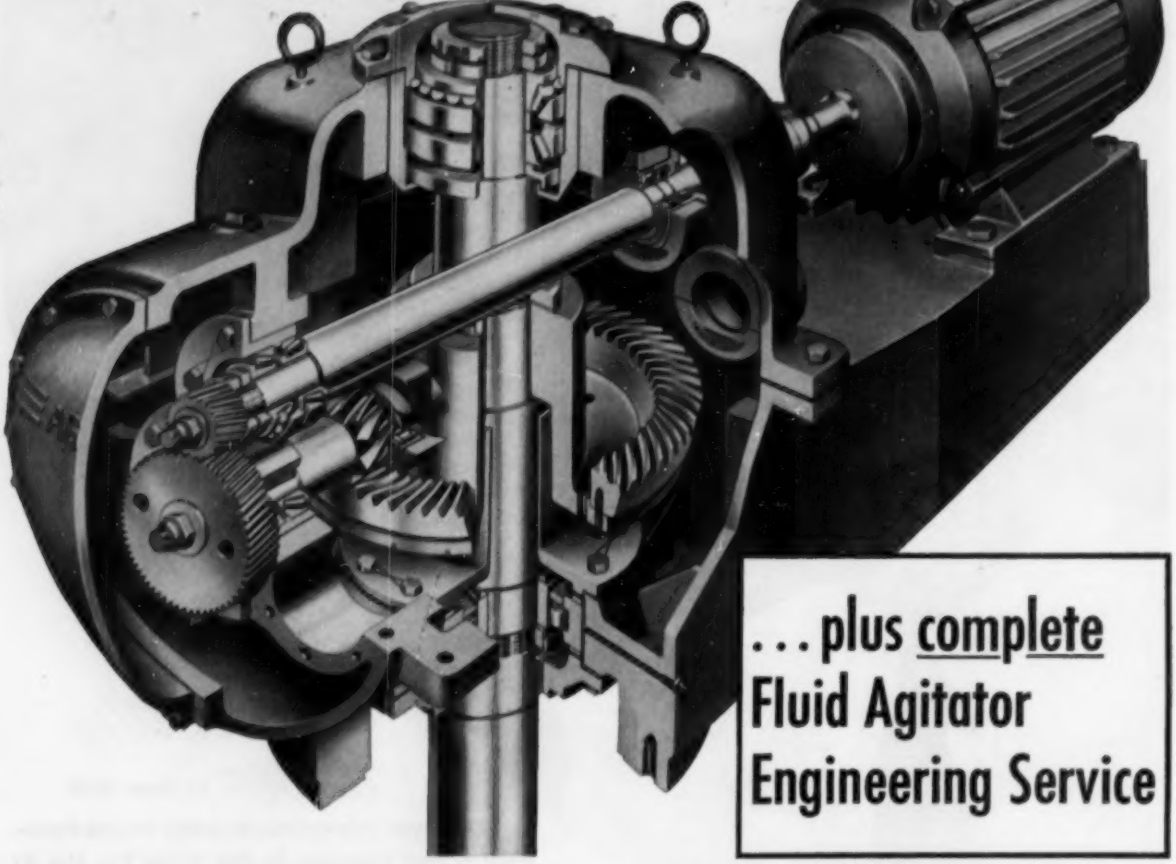
only PHILADELPHIA gives you all these features



...plus complete Fluid Agitator Engineering Service

Now, for the first time one manufacturer is able to offer a completely integrated, "packaged" fluid agitator service. No other manufacturer controls, within its own organization, such extensive and specialized designing, engineering, manufacturing, assembling, testing, and field servicing facilities devoted exclusively to fluid agitator production. Philadelphia Gear Works manufactures impellers, shafts, drive supports, all gears, and reducer housings. Only Phillie Gear can offer you the complete solution of your fluid agitator problems—through one centrally-controlled, thoroughly responsible source.

Our engineers are familiar with the requirements of all types of process mixing and fluid agitation applications.

Philadelphia Gear Works products have "measured up" through 63 years of industrial leadership. Compare the new Philadelphia Fluid Agitators for economy, efficiency and quality. See for yourself why Philadelphia Fluid Agitators are your very best investment.

COMPARE THESE FEATURES: Exclusive Philadelphia Low Head Room Design—maximum bearing span with minimum headroom ● Helical Change Gear Set, within housing, allows for ready selection of up to 14 different standard speeds ● Heavy Duty Thrust Bearings permit use of standard units for conditions of high pressure in closed tanks ● Large Heavy Duty Output Shafting results in less shaft deflection at stuffing box or mechanical seal, steady operation of long overhung agitator shafts ● Philadelphia Heavy Duty Inboard Bearing Support provides extra rigidity resulting in superior gear performance and life ● Spiral Bevel Gears of Hardened Steel, accurately lapped for long and quiet operation ● Field-proven Philadelphia Dry-Well Construction prevents oil leakage down output shaft ● Labyrinth-type seal on input shaft allows effective sealing with minimum friction ● Ask for Bulletin A2-55.

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LimiTorque Valve Controls

Established 1892

ammonia

1,035 tons/day from seven FW plants

This Tonnage capacity is a measure of *experience* that can be a valued asset to prospective ammonia producers anywhere in the world.

Seven modern synthesis plants, completed or under construction by Foster Wheeler — total capacity, 1035 tons of anhydrous ammonia per day!

Foster Wheeler's specialized know-how embraces all phases of process and equipment design, fabrication and erection. For complete information, write for Bulletin 0-54-1. *Foster Wheeler Corporation, 165 Broadway, New York 6, N.Y.*

Designed and engineered by our Paris office, this ammonia plant at Cubatao, Brazil, is being erected by 100 per cent Brazilian labor. It is a typical example of the flexibility and world-wide coverage of Foster Wheeler's engineering and construction services.

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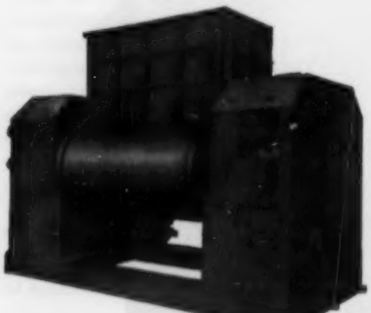
READCO'S IMPROVED MIXER DESIGN PROVIDES COMPLETE DISPERSION IN LESS TIME...FOR LESS COST



READ STANDARD CORPORATION

Bakery-Chemical Division
YORK, PENNSYLVANIA

It's Readco's unique split-level dispersion bowl that makes the difference. It provides a greater ratio of surface to the volume of mix. Overlapping sigma arm mixing action exposes new surfaces and breaks down the entire mass with each rotation, producing a homogenous mix in a short mixing cycle, eliminating peak loads. Closer clearances between mixer arms and shell prevent build-up of materials.

Readco Paper Coating Mixers can be supplied for manual or hydraulic discharge in 150, 350 and 750 gallon working capacities. Write for complete information.

Noted and quoted

(Continued from page 24)

UNESCO—The First Nine Years

More effective interdisciplinary pooling and dissemination of information should be developed for the purposes of advancing science, as well as public understanding of scientific matters, by the following: (i) Establishment of local and national committees on arid-zone problems to enlist public interest in support of studies of arid lands and the dissemination of information on results of such studies in each country. . . . It is strongly urged that they [Committees] be broad in scientific disciplines and in representation from both private and public agencies. These committees should operate in a manner best suited to the interests and possibilities of each country and should be aimed at encouraging research and spreading information, utilizing UNESCO as a clearinghouse . . . .

(ii) Creation of a preliminary project to explore the feasibility of an abstracting service on arid-zone literature. A periodical, patterned after existing successful abstracting journals, would include, as soon after original publication as possible, abstracts of technical, economic, and social literature related to arid-zone problems and research. A target date for the report on this feasibility study should be 1 year from the adoption of this recommendation by some agency capable of committing funds. (iii) Encouragement of the formation of research organizations, comprehensive in discipline and concerned with the best use of specific limited resources. Such organizations should be encouraged in all arid lands through adequate and broadly based financial support.

Peter C. Duisberg
in "Man Against The Desert," Fifth National Conference, U. S. National Commission for UNESCO
Cincinnati, Ohio,

French Institute for Nuclear Science

An Institute for the training of engineers and technicians in the Nuclear Sciences is to be set up at the Centre for Atomic Studies at Saclay, just outside Paris. The new centre will organize advanced courses in nuclear science in collaboration with French universities, and will also follow closely industrial developments in atomic energy.

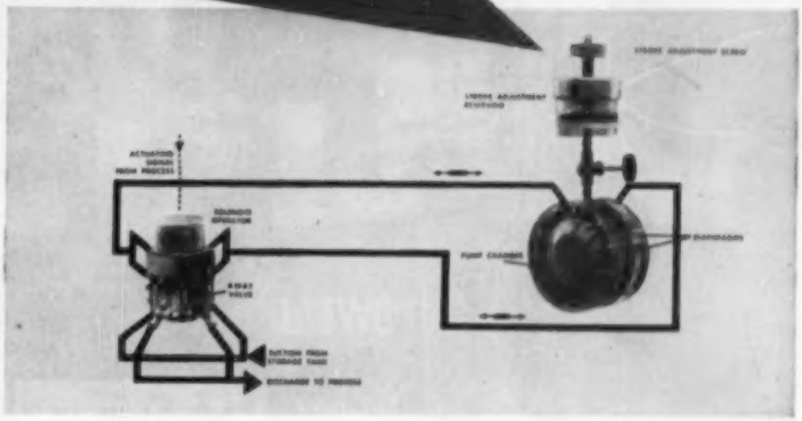
(UNESCO)
United Nations Educational, Scientific and Cultural Organization

(Marginal Notes on page 36)

NOW! Downhill metering!

the new
MILTON ROY
$-\Delta$ P PUMP
(MINUS DELTA P)

In operation, the four-way valve admits fluid to one side of the pump chamber, forcing a slack diaphragm to displace fluid from the opposite pump chamber. This procedure reverses on the next cycle. The pacing valve can be operated manually, mechanically, electrically, or pneumatically.



FEATURES

Leakproof

No stuffing box

No running seal

No contamination

No lubrication

Accuracy within plus or minus 1%

Easily dismantled

LITERATURE

For complete details write today for *Bulletin 955!* Milton Roy Company, *Manufacturing Engineers*, 1300 East Mermaid Lane, Philadelphia 18, Pa.

TELL US YOUR PROBLEM

Milton Roy engineers will gladly analyze your operation and advise you of the ways "downhill metering" might be applied in solving your particular pumping problem. Write us today.

Downhill metering (controlled volume pumping from higher to lower pressures) is now practical. The $-\Delta$P pump uses a new concept in controlled volume pumping to meter clear fluids (liquids or gases) wherever suction pressure is at least 5 psi greater than discharge pressure.

External power sources are often unnecessary since the $-\Delta$P pump can use the potential energy of the fluid (stored either under pressure or in an elevated location). The basic leakproof diaphragm design (for both meter and pacing valve) and a wide selection of materials of construction make the $-\Delta$P pump particularly adaptable to handle corrosive or hazardous fluids. For specification data, write for Bulletin 955 . . . to Milton Roy Co., 1300 E. Mermaid Lane, Phila. 18, Pa.

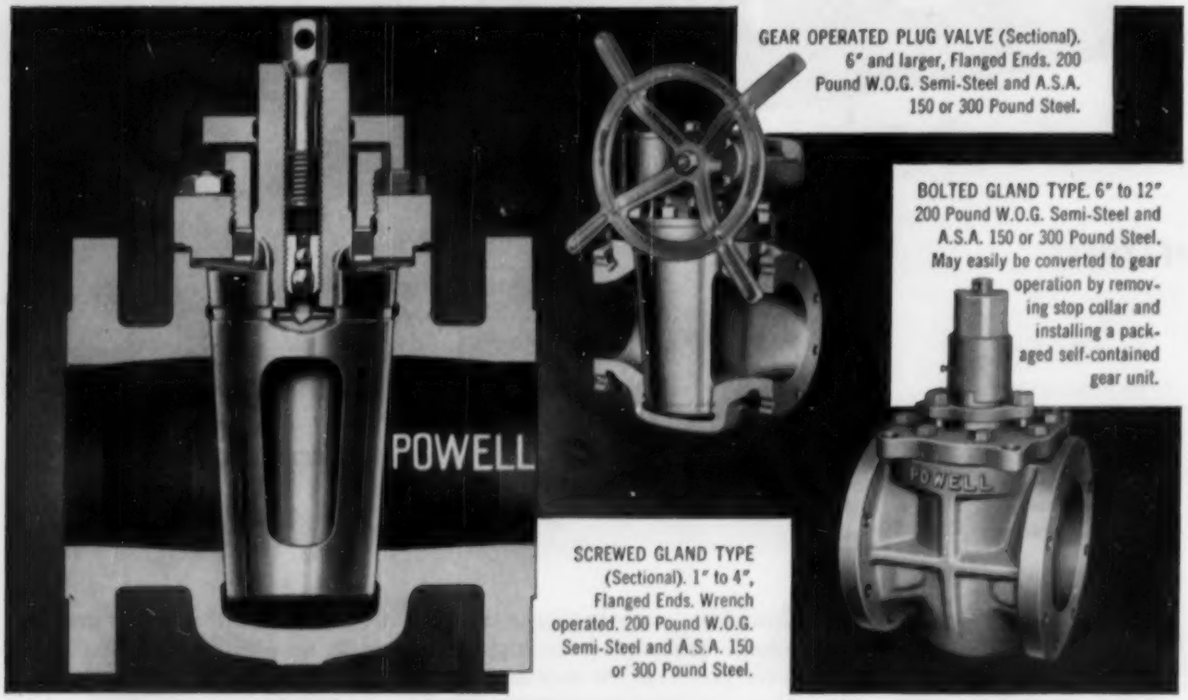
Engineering representatives in the United States, Canada, Mexico, Europe, Asia, South America, and Africa.

Milton Roy
CHEMICAL FEED SYSTEMS

POWELL

Lubricated Plug

VALVES



GEAR OPERATED PLUG VALVE (Sectional). 6" and larger, Flanged Ends. 200 Pound W.O.G. Semi-Steel and A.S.A. 150 or 300 Pound Steel.

BOLTED GLAND TYPE. 6" to 12" 200 Pound W.O.G. Semi-Steel and A.S.A. 150 or 300 Pound Steel. May easily be converted to gear operation by removing stop collar and installing a packaged self-contained gear unit.

SCREWED GLAND TYPE (Sectional). 1" to 4", Flanged Ends. Wrench operated. 200 Pound W.O.G. Semi-Steel and A.S.A. 150 or 300 Pound Steel.

Powell Lubricated Plug Valves maintain our 110-year tradition of quality and precision. Only the finest available materials are used. And painstaking quality control is rigidly enforced through each and every step of manufacture.

Features include quick and positive operation—just a quarter-turn to open or close. Lubricant grooves surrounding each port provide a positive seal when the valve is closed. In an open position, seating surfaces are not exposed.

Valve users who want one source of supply for lubricated plug as well as all types of bronze, iron, steel and corrosion-resistant valves will want full details on Powell Lubricated Plug Valves.

Available in Steel and Semi-Steel through distributors in principal cities. If none is located near you—or if you need help on valve problems—write direct to

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The painstaking care with which GLC carbon and graphite products are prepared for shipment is typical of the interest taken by our personnel—all along the line—to achieve unsurpassed quality.

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When you invest hundreds of thousands of dollars in a cooling tower, what you are actually buying is the tower's consistent ability to deliver *cold water* at specified temperature and volume . . . at an economical price per gpm.

And because actual performance is an "unknown" until the tower is in operation, you purchase cooling towers largely on faith in the manufacturer.

You can place your absolute confidence in The Marley Company's ability to deliver the cold water you specify. At Marley, water cooling has been an exclusive specialization—not a sideline—for 35 years. Every company facility—design, research, engineering, production—is devoted 100% to the science and techniques of water cooling. This single-minded approach to water cooling problems has resulted in Marley's undisputed leadership in the water cooling field by any standards you care to apply.

The Marley Company, however, does not ask you to buy its cooling towers on blind faith. Rather, Marley urges every industrial tower owner to test his tower and has paved the way by developing the simplest and most authoritative tower-testing procedure. And finally, every Marley cooling tower, from the moment it starts, receives the benefit of professional observation and inspection by Marley field engineers—specialists in maintaining both tower function and tower structure in excellent condition.

The Marley Company MARLEY
Kansas City 14, Missouri

Marginal notes

Diffusion and Heat Exchange in Chemical Kinetics. D. A. Frank-Kamenetskii. Translated from the Russian edition by N. Thon. Princeton University Press, Princeton, New Jersey (1955), 370 pages, $6.00.

Reviewed by Stuart W. Churchill, Department of Chemical and Metallurgical Engineering, University of Michigan, Ann Arbor, Michigan.

This translation of a book published in Russia in 1947 is concerned with the role of heat and mass transfer in chemical transformations and in combustion in particular. Primary attention is given to the investigations of the author and his colleagues at the Institute of Chemical Physics of the Academy of Sciences of the U.S.S.R. As such, the book serves as a selected review of Russian work in this field through 1946.

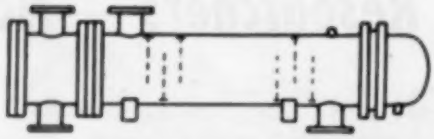
Chapter I considers the mathematical description of chemical kinetics, heat and mass transfer. Diffusion and combined diffusion and chemical reactions are treated in the next three chapters. Chapter V describes the velocity distribution in flowing fluids and hence with turbulent exchange of heat, mass and momentum. The last five chapters discuss ignition, flame propagation, explosions, oscillating reactions, and other aspects of combustion.

Emphasis is placed upon the formulation, analysis, and interpretation of complex processes in terms of dimensionless groups. Experimental correlations of rate data are referred to only superficially, and formal solutions and derivations are considered for only a few problems. Nevertheless, considerable insight into the role of heat and mass transfer in complex processes is achieved by this semiquantitative approach. The value of the book is principally in illustration of this method.

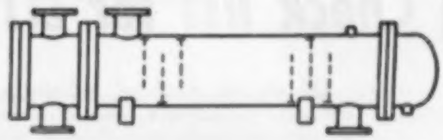
Details of the treatment of heat transfer, mass transfer, and in particular, momentum transfer are questionable in many instances and are seriously dated. For example, Chapter V, "Chemical Hydrodynamics," is devoted largely to proving the existence or nonexistence of a laminar sublayer near a surface. Since the various descriptions of the velocity distribution are compared with one another rather than with experimental data, the conclusions are not only vague but irrelevant. The examples of complex processes are almost all chosen from the field of combustion. Packed- and fluidized-bed reactors are all but ignored.

The translation itself is commendable.

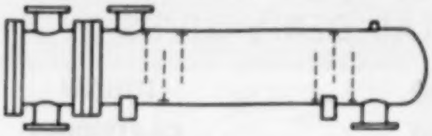
(*Continued on page* 42)



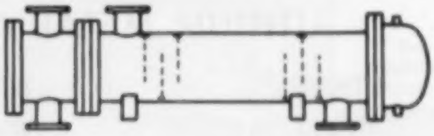
Type SG straight tube, outside packed lantern gland design. Eliminates undetected fluid inter-leakage.



Type S pull-through floating head design. For condensing, heating services . . . easy maintenance.



Type R U-tube design. Low cost construction, for non-fouling service.



Type ST conventional straight tube, split ring, floating assembly construction.

HOW YOU CAN SAVE WITH Whitlock Standardized Heat Exchangers!

SAVE WORK . . . "prints for approval" can be supplied quickly for piping and other layouts.

SAVE ENGINEERING COSTS . . . our engineers will help you select a standard design suited to your requirements.

SAVE DELIVERY TIME . . . many units can be manufactured promptly from stock materials and sub-assemblies. Also, completed units are often in stock for immediate shipment.

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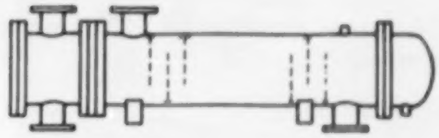
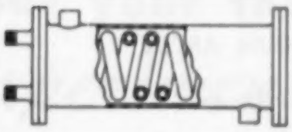
Compare costs . . . compare *savings*. It pays to consider Whitlock Standard Exchangers *first*. Send for Bulletin 250. The Whitlock Manufacturing Co 97 South St., West Hartford 10, Conn.

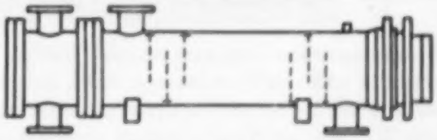
Whitlock



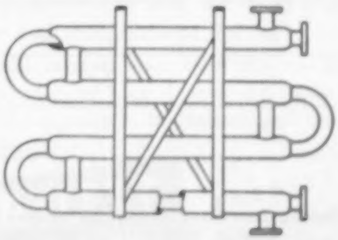
Straight tube, fixed tube sheet design. Types V and V-1 — for easy mechanical cleaning.



Type C coil type heat exchangers. For high tube side pressures.



Floating head heat exchangers. Type SO with outside packed head — no concealed, bolted and gasketed joints.



Double pipe heat exchangers. For counter-temperature flow conditions and low flow rates.

Designers and builders of bends, coils, condensers, coolers, heat exchangers, heaters, piping, pressure vessels, receivers, reboilers.

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Lithium has enabled industry after industry to achieve over-all savings through shortcuts, reduction of waste, improvement of end-product, and simplification of operating procedures. Check your field of interest in Lithium below. If you are interested in a specific application relative to Lithium not indicated in the checklist, note the fact in the form furnished, attach it to your letterhead and send it to us. Our research laboratory will look into the matter for you.

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LITHIUM RIBBON WIRE AND SHOT

Uses:

- ☐ Preparation of new drugs
- ☐ Organic chemicals

LITHIUM CARTRIDGES

Uses:

- ☐ Refinement of alloys (copper and aluminum)
- ☐ Aluminum castings
- ☐ Brass, bronze and nickel-silver castings

LITHIUM AMIDE

Uses:

- ☐ Preparation of Organic chemicals

LITHIUM HYDRIDE

Uses:

- ☐ Organic chemicals
- ☐ Pharmaceuticals
- ☐ Generation of hydrogen
- ☐ Reducing agent
- ☐ Drying agent

I am interested in Lithium ______________________________ for
(Compound, Metal or Derivative)

the following application: ______________________________

____

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Technical Data Sheets are available for every compound in the checklist. They will be sent as checked above.

...trends ahead in industrial applications for Lithium

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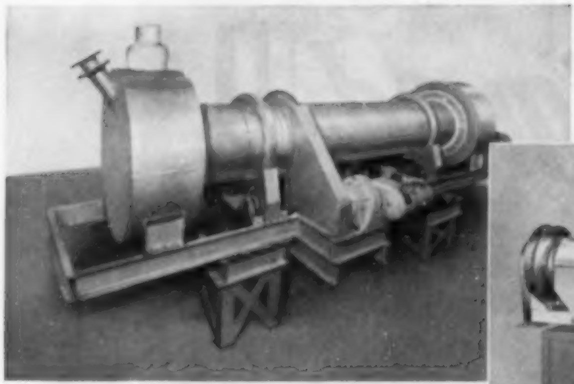
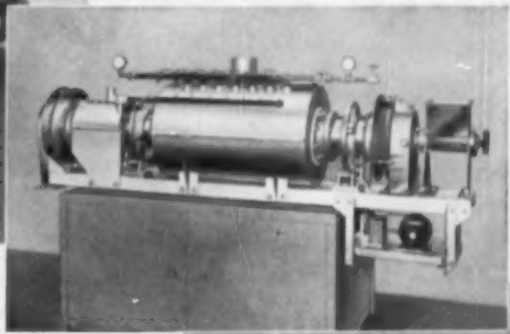
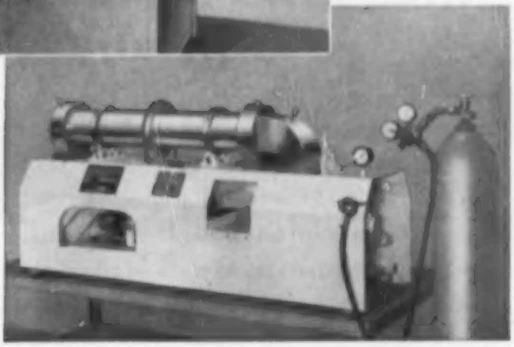


Experimental Size Rotary Kiln.



Gas-Fired Combination Calciner and Cooler.



Gas-Fired Experimental Size Rotary Dryer.

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Test out your theories in BARTLETT-SNOW *Experimental* UNITS

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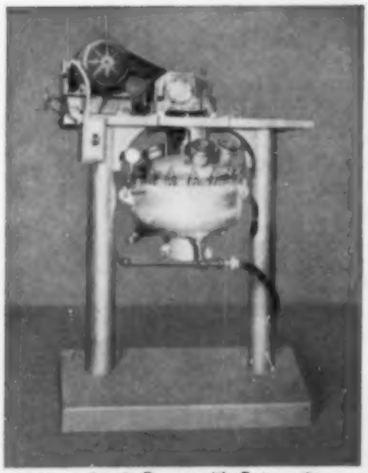

Pot Type Batch Dryer with Rotary Sweep.

Check carefully before you recommend construction of a costly semi-works or full plant operation. Determine accurately the heat sensitivity, permissible temperatures, entrainment losses, desirable velocities, balling, sticking, cooling and all other chemical and physical aspects of your product. Our complete line of laboratory size experimental equipment includes both a gas-fired and electrically heated continuous combination calciner-cooler; steam heated and gas-fired rotary dryers; pot type batch dryer with rotating sweep; and rotary kiln. Pre-testing can save you much embarrassment and thousands of dollars!

If not convenient to run tests at your own plant—arrangements can be made to run tests of 3 or 4 days duration in our Cleveland laboratory in the presence, if desired, and under the direction of your technicians.

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Custom Designed

For a Bigger Yield

Higher yield in your case may mean cleaner, dryer cake . . . or better recovery of solubles . . . or just plain fast, trouble-free operation on a job that's got to be done. If you can get a few points better efficiency at no extra cost, why not?

FEinc custom-designed continuous vacuum filters have been doing just this for 37 years: For instance:

- Replaced six settling tanks in recovering plastic grinding waste . . . paid for itself in 3 months
- Reduced moisture in iron pigment from 68 to 59%
- Cut recycling of difficult gelatinous sulphate cake from nine to five cycles
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- Recovered ⅔ of chromates left by competitive filter

All types of continuous rotary vacuum filters . . . string, horizontal, scraper, precoat, etc. . . . are custom designed and manufactured by FEinc . . . quality built because quality pays you. Ask for bulletins . . . or for recommendations . . . no obligation, of course.

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For a Bigger Yield

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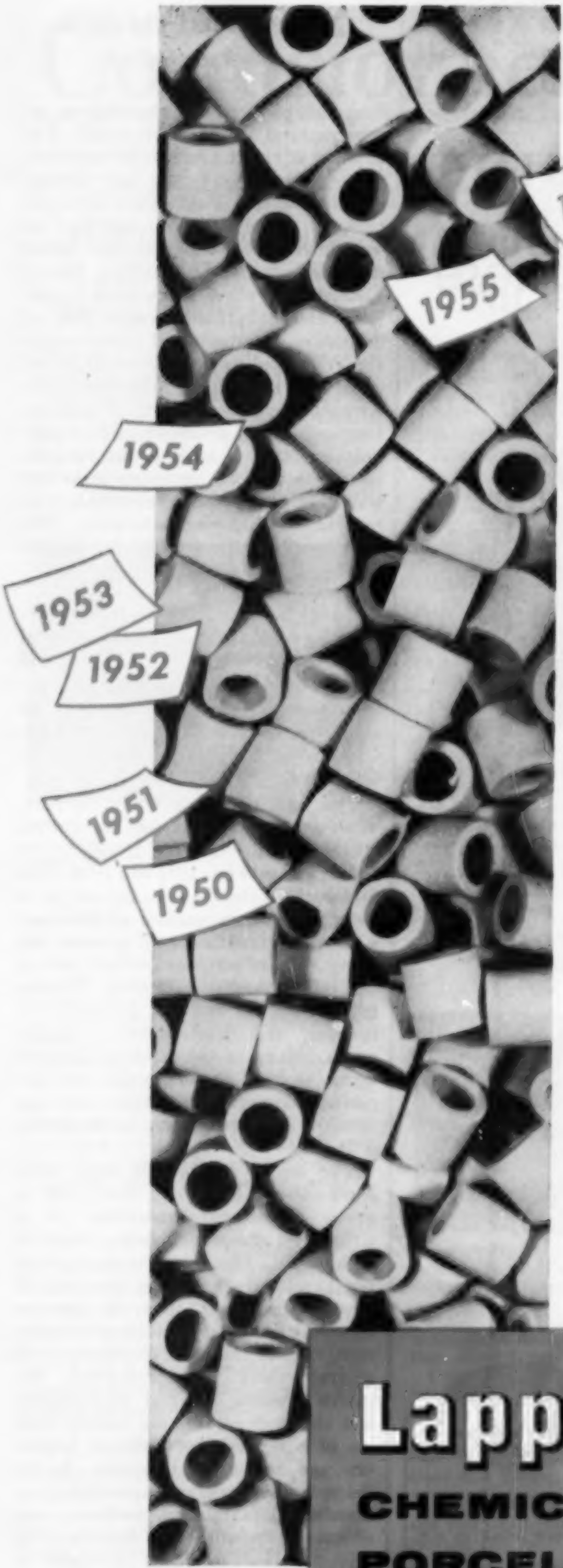

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...WITH LAPP PORCELAIN RASCHIG RINGS

Lapp Porcelain Raschig Rings are your best bet for Process Tower packing for two important reasons ... purity and strength. Lapp raschig rings are non-porous, completely vitrified and iron-free. They are chemically inert to acids of all concentrations (except hydrofluoric), will not crumble and will not absorb liquids which could later contaminate the product being processed.

As for strength, Lapp raschig rings are dense, hard and close-grained. They are tougher against damage from handling and tower operation than other ceramic rings or other packing shapes. Because Lapp rings are so strong and inert, they seldom need replacement. Hundreds of satisfied customers back up our claim of longer continuous service—with real savings. Get the full story on Lapp Chemical Porcelain—see for yourself how this initially low-cost material can save you money while providing a sounder processing system.

WRITE for our bulletin containing description and specifications. Lapp Insulator Co., Inc., Process Equipment Division, 832 Wendell St., Le Roy, New York.

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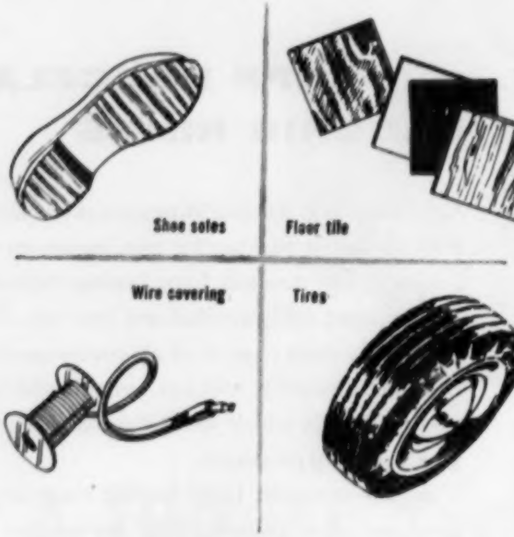
PANAREZ
HYDROCARBON RESINS
improve products like these



If you compound rubber it will pay you to investigate *low cost* PANAREZ hydrocarbon resins. These softeners are available in any color from Barrett No. 1 to 18, and softening point from 40° F to 300° F. They are supplied in flaked or solid form.

Compounds containing Panarez resins show **IMPROVED COLOR AND COLOR STABILITY . . . IMPROVED EXTRUDABILITY . . . IMPROVED FLEX CRACK PERFORMANCE and ABRASION RESISTANCE . . . IMPROVED OZONE RESISTANCE . . . IMPROVED TEAR RESISTANCE, TENSILE STRENGTH and ELONGATION.**

No change in compounding technique is required when switching to Panarez resins.

For confidential information about how these low cost resins might be helpful in your business, write us, telling the intended application.

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PANAREZ Hydrocarbon resins — **PANAPOL** Hydrocarbon drying oils — **PANASOL** Aromatic solvents

Marginal notes

(*Continued from page 36*)

Few ambiguities, misinterpretations, or typographical errors were noted. The notation does not conform to American practice, but doesn't offer any particular difficulties. Most important, the book, or at least the translation, is so well written that it may be read rather than studied.

Because attention is focused on formulation and interpretation rather than on derivation, mathematical complexities are minimized and the material is accessible to the casual reader who seeks a qualitative understanding of combustion and related processes. The rather unique method of analysis and the concern with complex processes make the book useful as a collateral reference or text in research and education. The book has little direct utility for process design.

Atomic Energy Research at Harwell. K. E. B. Jay. Philosophical Library, New York (1955), 144 pages, $4.75.

Reviewed by T. J. Connolly, Assistant Professor, Department of Engineering, University of California, Los Angeles, California.

This book is a summary of the technical work carried on at the British Atomic Energy Research Establishment at Harwell between 1951 and 1954. The first half of the book is devoted to a description of the various projects and is written primarily for the nontechnical reader. These projects include production of fissionable materials, development of nuclear reactors, production of isotopes, and development of instruments. Many of the problems attacked under each of these projects are discussed. Unfortunately, the solutions found are described only qualitatively, if at all.

The second half of the book, titled *Fundamental Research*, deals with a group of selected researches. It is written for the reader with a scientific background. However, the descriptions are necessarily brief. In the area of physics research, projects in neutrons transport theory, cross-section measurement, nuclear reactions, cosmic rays, and several others are summarized. Research projects reported in chemistry and chemical engineering include studies of heavy element chemical properties and separation processes. In the field of metallurgy some interesting researches in fabrication, corrosion, and effects of radiation are described. In several cases reference is made to further details in the literature.

(*About Our Authors on page 46*)

ADVERTISEMENT

Corrosioneering News

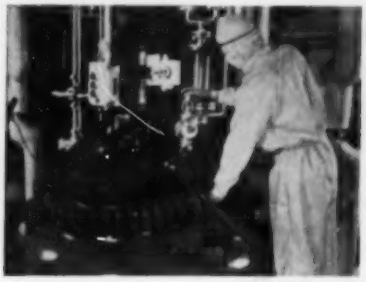
Quick facts about the services and equipment Pfaudler offers to help you reduce corrosion and processing cost.

Published by The Pfaudler Co., Rochester, N.Y.

How to protect color and purity of plasticizers during polymerization

Color and purity are the prima donnas of the polymerization process.

Contamination can spoil both. To avoid it, you need equipment that is easy to clean between each run, that resists the corrosive action of the chemicals involved, and that does not put metal in contact with your product.



This type of glassed steel kettle, used in the manufacture of polyester resin, helps protect product from contamination.

That's why Pfaudler glassed steel reactors have found universal application as polymerization vessels.

Practically nothing sticks to their glassed interior. They wash clean quickly and easily between runs, avoiding contamination of succeeding batches.

Resisting all acids (except hydrofluoric) and alkaline solutions up to pH 12 and 212° F., Pfaudler acid-alkali-resisting glassed steel protects your product from contamination and protects your equipment investment from excessive replacement needs.

Full year's guarantee against corrosion

In fact – the corrosion resistance of Pfaudler glassed steel is so well documented that we offer a full year's guarantee against corrosion destruction, under the conditions for which the vessel is sold. 12 months of 100% freedom from corrosion, even if you process 24 hours a day!

Nonmetallic

Contamination by metals – particularly iron – can cause discoloration of your product. You get the tremendous strength of steel, but not the ferric contamination, when you use glassed steel. The glass is permanently bonded. It doesn't peel or flake off.

Write or call for additional details.

Hundreds of stainless steel dimples cut kettle costs as much as 20%

If you need a jacketed stainless steel reaction kettle – for nonpressure use, or for high pressures – you can cut up to 20% off its initial cost with the Pfaudler dimpled jacket design.

This exclusive design permits the use of a lighter gauge metal in the jacket, yet strengthens the metal to the point where it is as strong as, or even stronger than a nondimpled, heavier jacket would be.

Specially built dimpled jacketed reactors, like this one, have been fabricated as large as 7,000 gallons.

The dimples are hundreds of indentations with reinforced welds, and they are obtainable in low-cost *standard* reactors from 750 to 2000 gallons. Jackets may be either carbon or stainless steel.

You get greatest savings on reactors requiring a jacket pressure of 150 psi, but even when you only plan to use 50 psi, the Pfaudler dimpled jacket uses less material and costs less than conventional jacketing.

Besides the standard designs up to 2,000 gallons, you can also enjoy the benefits of this dimpled construction in special custom reactors built to meet your special needs.

The National Board of Boiler and Pressure Vessel Inspectors have approved this construction for 150 psi jacket pressure, and we can supply vessels bearing the code stamp.

Heating and cooling is as fast as with conventional jackets, and in many cases has proven faster.

If heat treating is desired, Pfaudler has complete facilities to heat treat stainless steel jackets of this dimpled type, giving you exceptionally long-lasting equipment.

Low-priced heat exchanger has 8 valuable virtues

An electronically controlled roller expander locks the tubes in position in the tube sheet during careful fabrication at Pfaudler.

Pfaudler fixed tube sheet heat exchanger is simple in design, hence costs you less than other types.

Fabricated from stainless steel or alloys, it gives you a number of advantages. Here are eight:

1. Versatility – Most widely used type of heat exchanger in the chemical industry. Used as a heater, cooler or condenser.

2. Easy cleaning – Tubes are straight and you clean them easily by simply removing the heads. Shell side may be flushed with chemical solutions.

3. Low cost – Because of large quantity production, standardized design, and use of full tube bundles, prices of fixed tube type heat exchangers are the lowest per square foot of any heat exchanger.

4. Fast delivery – A large number of Pfaudler fixed tube sheet stainless heat exchangers are maintained in stock, and you can often get delivery within one week when required.

5. Replacement of parts – Pfaudler carries a complete line of standard heat exchanger parts in stock and shipment may be made on short notice.

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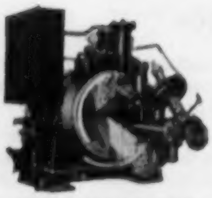

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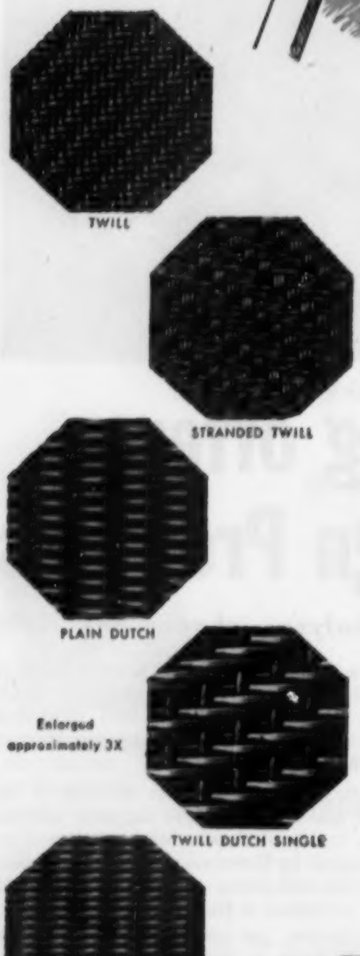
...says STOP to Solids



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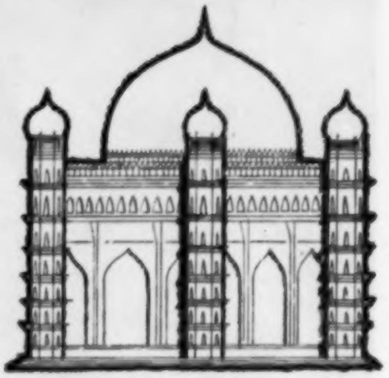

International Chemical Engineer

M. S. Patel, author of the article "Coal Carbonization" appearing in this issue, comes very close to living up to the "international" title. Headquartering at Bombay, India, he is a world traveller—most always on chemical engineering projects. He was in and out of the U.S. twice while we were readying his manuscript, the first time on his way to Iceland. He was consulting there with regard to the harnessing of volcanic steam for production of salt from sea water.

Patel was also instrumental in getting the unusually flexible coke plant described in this article built in India. He received his chemical engineering training in the U.S., getting a Ph.D. from Cornell.

Self-Starting Surveyor

Carl W. Barkow, author of the two-part article "The Project Engineer" (March & April C.E.P.), did the unusual. Employed in the Oak Ridge Laboratories as project engineer in the Plant Engineering Division, he not only had an idea that making a survey of project engineering operations would be a good idea—he did something about it. In addition to other benefits, the study serves as partial fulfillment towards his M.S. degree in business administration.

Carl states that his ten years' experience in project engineering work caused him to wonder a great deal about what the other fellows' jobs were like, how much responsibility they were able to carry, and so on. The survey does, therefore, seem to be a realization of an ambition of many years.

On the humorous side, Carl reports that one reply to his survey stated there was only one engineer in the "Engineering Division," in which case there were no known organization problems having to do with team work, empire building, and overlapping of duties. However, communications were said to be sometimes complicated in that the engineer would on occasion talk to himself!

Unsung Author of the Month

Bill Keppler, chairman of the Central Pennsylvania Section, writes, "I received a small disappointment when the March C.E.P. arrived. My 'moment of glory' had passed me by—my first article was published in C.E.P., but my name as contributor was omitted."

Our apologies to author Keppler for dropping the credit line on his fine article "Industrial Recruiting in Colleges," page 100. Also, our thanks to him for letting us know.

Award Winner

F. C. Jelen won the A.I.Ch.E. award for the best presentation of a paper at the recent Los Angeles meeting. Mr. Jelen is a corrosion engineer with the Solvay Process Division of Allied Chemical & Dye Corp. at Syracuse, N. Y. He was granted the award for his paper "Comparison of Alternatives by Capitalized Cost" which is to appear in a future issue of C.E.P. dealing with *interpretation* of cost estimates. (This May issue deals with the *preparation* of cost estimates.)

The award committee's announcement of its decision explained that "Dr. Jelen's formula for the technical talk presentation is summed up in the word 'put.' He felt that in order to 'put' across the point of a talk, the first important point is (P) preparation. The next quality is (U) unity. In other words, if the talk can leave the audience with one main thought which they will retain and understand, it is far better than to leave them confused. The 'T' stands for timing."

While the above points might be difficult to apply to all types of subjects, they might bear careful consideration.

L. to r., Richard Hiserodt; F. C. Jelen, recipient of the award; and H. P. Munger, chairman of the Syracuse Chemical Engineer's Club, making the presentation.

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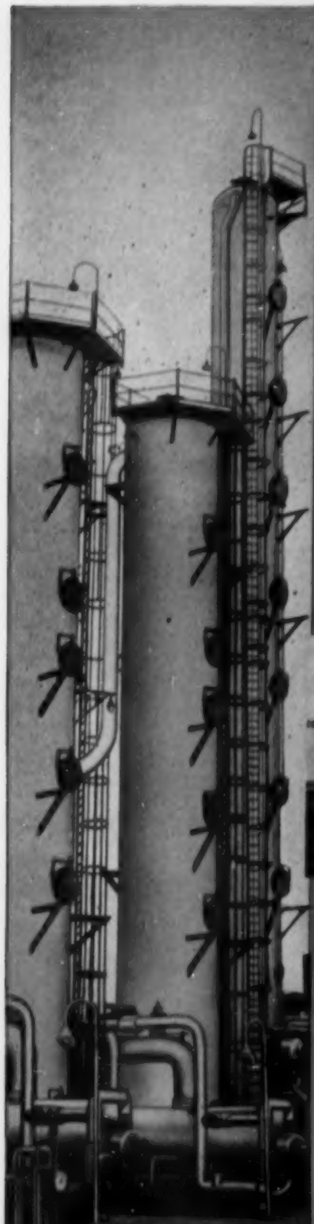

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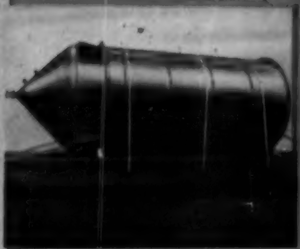

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CEP trends / FOREIGN CHEMICALS

The rapid recovery of the European chemical industry since the war is becoming an increasingly important factor to the American industry.

It obviously means more competition for American manufacturers, both in this country and in Latin American markets.

Price Competition

For some time Italian suppliers had been selling vinyls below the stated American market prices until major American producers finally met the Italian price level. Market prices for vitamins have been highly competitive due largely to imports from Europe and Japan. Foreign dyes have been a severe headache to American dye firms both here and in fighting an apparently losing battle in Latin America.

Although American industry has been chalking up notable sales gains since the war, the improvement of the rehabilitated European producers has been equally impressive. In the three year period from 1951 to 1954, chemical output in France increased 18%, in Great Britain 27%, in West Germany 48% and in Italy 56%.

Most striking has been the comeback of the split up parts of the old German chemical trust I. G. Farben, even though it lost 60% of its facilities to the Russians and suffered heavy bombing damage to plants and equipment.

It begins to appear that the German chemical octopus may be comparable to the split up of the original Standard Oil Co. in this country, with the parts becoming as strong as the whole.

Partnerships

Partnership arrangements between American and European firms offer many advantages to both. These partnerships may involve joint ownership of plants in this country such as Mobay Corp. formed by Monsanto Chemical Co. and Fabrikwerken-Bayer to make isocyanates, or the more recent deal between Pittsburgh Coke & Chemical Co. and Farbenfabriken Bayer to consolidate their agricultural chemical activities in this country. For a smaller firm like Pittsburgh Coke, which is not a leader in research, to have the partnership of a firm like Farben obviously carries large advantages.

Another kind of partnership arrangement is exemplified by that between W. R. Grace & Co. and Farbwerke-Hoechst of Frankfort, a former Farben division, to make low pressure polyethylene plastics in Brazil, where the partners now make insecticides. Monsanto Chemical Co., which already has extensive foreign holdings, has recently bought an interest in a Spanish firm which will make polyvinyl chloride and polystyrene. Most of the big drug firms in this country, many of which have 30% of their sales volume outside the U. S., have manufacturing plants in the nations where they sell.

Petrochemical Growth

In recent years an important petroleum chemical industry has been growing up in France, in Great Britain, and in Italy. Germany has long been a pioneer and a leader in acetylene chemistry. Oil supplies from the Middle East furnish the raw materials for these ventures.

Great Britain is already an important producer of polystyrene from petroleum. A leader in the petroleum chemicals field in England is Petrochemicals, Ltd., an affiliate of Manchester Oil Refinery, Ltd. which produces benzene, ethylene glycol, and isopropyl alcohol, among other products. Important amounts of detergents from petroleum are being produced, notably by Shell Chemicals, Ltd.

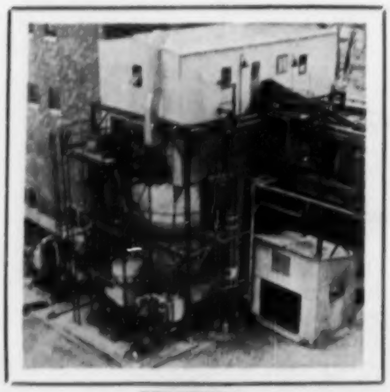
France is becoming increasingly active in petrochemicals, although the industry there is only about six years old. Shell is a producer of detergents. Naphtachimie, a leading petrochemical producer, is now planning new facilities to cost about $30 million which will more than double its present output of 8,000 tons of ethylene oxide annually. Ethylene glycol will also be produced. Although direct oxidation of ethylene was conceived in France over 20 years ago, commercial production did not come until the first Naphtachimie plant went on stream in 1953.

France is aiming some of its petroleum chemical production at styrene and acrylonitrile. It already produces acrylonitrile for fibers. France still imports twice as much plastics as it produces but with its own production growing it may in future years buy less from this country. Production of plastics grew from 2,000 metric tons in 1949 to 95,000 metric tons last year.

The latest comer to the petroleum chemical field is Japan, which expects to be in production of ethylene and ethylene-based chemicals by the end of this year. The nation is also rapidly expanding its production of plastics. As recently as five years ago plastics production there was negligible, but last year was over 350 million pounds, mainly ureas, vinyls, and phenolics. By the end of this year the nation expects to be producing about 40 million pounds of polyethylene and over 6 million pounds of polystyrene.

Foreign Discoveries

Although the United States has run far ahead of other nations in the production of newer chemicals, especially those in the petrochemical group, it should be recognized that some of our most important new product processes have been discovered not here but abroad. A new polypropylene developed in Italy offers interesting possibilities for low cost new plastics and synthetic fibers.



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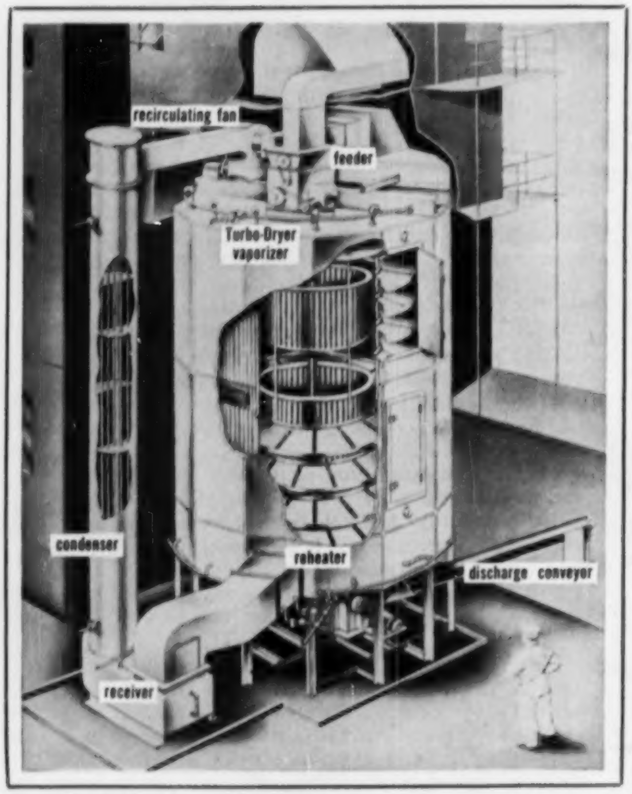
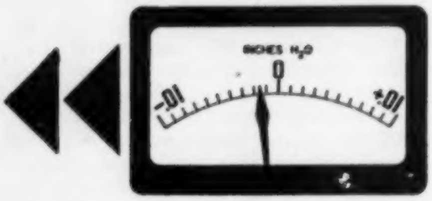


The Turbo Dryer consists of a tray rotor, centrally located turbo fans and insulated housing. The product on each tray is wiped off after the tray completes one revolution, falling on the tray below in a pile, which is leveled. From the lowest tray, the product drops onto the dryer bottom, whence it is swept into the discharge spout.



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opinion and comment

Industry and Education

SHOULD industry, the largest user of technically trained men and women, have more to say about their training? Some say "yes," others "no." Among the affirmative group are those who would gladly have industry go so far as to foot a sizeable portion of the cost for graduate training in fields where the recipients of the higher degrees will almost certainly go into industrial employment.

An analytical approach to this subject of what industry's role with regard to education should be was taken recently by the president of the State University of New York, William S. Carlson. Mr. Carlson spoke before a luncheon attended by more than 400 elementary school educators and representatives of industry, held in New York in observance of Chemical Progress Week.

Appearing under the sponsorship of the Manufacturing Chemists Association and representing the views of many in education, Mr. Carlson took an interesting stand on several issues.

With regard to the community of interest between industry and education, he was unhesitating in his endorsement of the policy that only through better cooperation will the needs of both be met in the present and in the future.

It was in the area of *how* industry could achieve closer liaison that Mr. Carlson indicated concern. Educators, he stated frankly, are fearful that there might develop pressure for courses providing a heterogeneity of the specialized training industry might happen to need at the moment. This, in place of the educational goal of better training for life and citizenship as well as for work, is certainly not to be desired. Nor would *it* seem to be the goal of enlightened and responsible management in the process industries of today.

The greatest aid to education can come, says Mr. Carlson, through industrial people lending their influence and efforts primarily at the local level through established agencies. These include membership on the School Board, or Board of Finance, along the lines described in the article by W. R. Collings on page 82 of this issue. It means tackling such matters as adequate financial budgets to maintain efficient and attractive schools staffed with able teachers who are proud of their occupation and able to live on a basis comparable with others of similar training working in industry.

He shares the views of those who in these pages have argued that schools should teach basic principles, leaving the techniques to the working experience.

It is for all of these, and many more, reasons that he asks that industry, while granting support, leave the matter of how to educate and what with to the professional educators.

This interesting essay on a large and complex problem has many parts with which most of us could agree, and should support. But the idea of leaving too much to the local level approach is to us not fully satisfactory. Mr. Carlson does have an answer to this, citing a national organization, the National Citizens Commission for the Public Schools, which is worthy of support.

It was doubtless a concern with bringing this problem into top level focus that brought President Eisenhower to create recently a National Committee for the Development of Scientists and Engineers. This action, reported on page 102 of this issue, should provide the inspiration and leadership to define the problem and perhaps to institute some actions which might otherwise seem bold or ill advised.

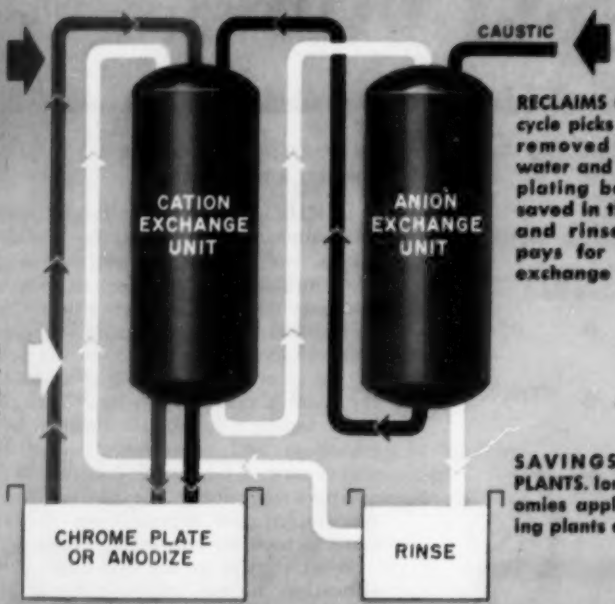
J.B.M.

PROCESSES: Ion exchange "swaps" chemicals in solution at high speed . . . purifies, recovers, concentrates, separates. An example:

How Ion Exchange Cuts Plating Costs

RENEWS PLATING BATH. This cycle removes aluminum, copper, iron and other impurities . . . allows continued re-use of bath . . . eliminates disposal problem. Compared with the usual toxic-waste disposal equipment, ion exchange saves up to 50% on initial costs, 75% on operating costs, 80% on floor space.

RENEWS RINSE WATER. Cation unit removes metallic impurities . . . anion unit removes chromic acid . . . allowing continued reuse of rinse water. Cuts consumption 90%!



RECLAIMS CHROMATE. This cycle picks up chromic acid removed from the rinse water and returns it to the plating bath. Chromate saved in the plating bath and rinse water often pays for the entire ion exchange installation!

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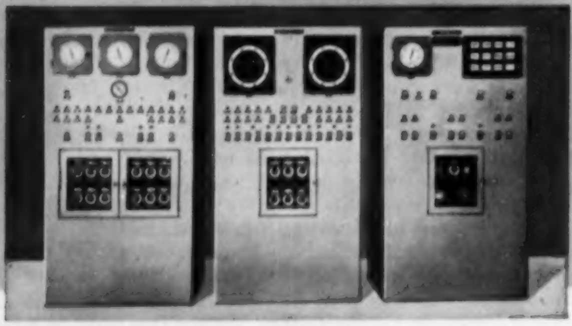

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• **Process applications:** Removing impurities from formaldehyde, glycerin, alcohol, plating baths and other chemicals, also wines, sugar solutions; recovering copper and zinc from rayon plant wastes; concentrating metals in dilute solutions such as plating rinses, mine waters; removing iron from phosphoric acid pickling solutions; producing colloidal silica used in textiles, waxes, foundry molds; making antibiotics, e.g. streptomycin, and other medicinals.

• **Largest manufacturer** of ion exchange equipment, The Permutit Company (N. Y.), got a head start in ion exchange with the natural zeolites first used in water conditioning . . . now manufactures highly efficient synthetic resin ion exchangers of all types. Permutit is the only U. S. producer of both resins and equipment. Making both allows proper "mating" of the two . . . enables Permutit to take responsibility for performance of the entire installation.

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L. to r., Moderator Alexander (Monsanto), Adams (Dow), Houlgrave (Amoco), and Street (Diamond Alkali).

Representatives of six major Texas-Gulf process operating firms and one engineering contractor held special Houston, Texas

SYMPOSIUM ON CAPITAL COST ESTIMATION

under sponsorship of C.E.P.

From this highly condensed transcript (original recording time 4 hours 39 minutes), one can gain insight into the techniques and problems having to do with:

- **How engineer-contractors prepare proposal-type estimates, which, if too high, may result in loss of job, or if too low, direct out-of-pocket loss . . .**
- **How the great Texas-Gulf petrochemical, electrochemical, and refining plants prepare their evaluation (feasibility) and appropriations type estimates . . .**
- **What their managements expect of (and do with) these estimates . . .**
- **The degree of accuracy achieved by the estimators . . .**
- **How experience factors are derived and used, and limitations of "factored" estimates . . .**
- **The uses and limitations of cost charts . . .**
- **How operating firms generally estimate their own utilities supplies.**

PANEL MEMBERS

ARNOLD ALLEN: The Lummus Company, Houston, Texas. In charge of preliminary design, estimating and proposals.*

J. O. ADAMS: Dow Chemical Co., Freeport, Texas. Engineering manager of cost control.

C. J. HOULGRAVE: American Oil Company, Texas City, Texas. Chief refinery engineer.

J. W. YOUNG: Humble Oil & Refining Co., Baytown, Texas. Project engineering supervisor.

NORMAN G. BACH: Monsanto Chemical Co., Plastics Div., Texas City, Texas. Senior estimator.

RAY V. SMITH: Carbide & Carbon Chemicals Co., Texas City, Texas. Works engineer.

JOHN STREET: Diamond Alkali Co., Deer Park, Texas. Senior engineer of projects group, Engineering Dept.

MODERATOR

WAYNE ALEXANDER: Plastics Div., Monsanto Chemical Co., Texas City, Texas. Assistant director of engineering.

* Present address: The H. K. Ferguson Co., San Francisco, Calif.

Editor's Note: On these pages are excerpts from some four hours of recorded discussion. Care has been taken to retain the essential character and subject coverage. As a final check, each participant was asked to look over C.E.P.'s condensed version to make certain that the original meaning was retained.

MODERATOR: We are here for the purpose of discussing "how costs are estimated." Each of us represents a sizeable organization in a growth industry, and has had considerable experience with the kind of project work which should provide the basis for a lively and informative discussion. In addition to those of us from chemical or petroleum refinery operating companies, we purposely invited Arnold Allen as representing a major engineering contracting firm active in our area. This should enable us to discuss both approaches—that of the operating company and that of the engineer-contractor. I'd like to ask Arnold to start off by describing how a contractor prepares estimates and how he defines equipment.

ALLEN: When we (Lummus) make up an estimate we would include these items: *basic equipment,* which we define as fired heaters, furnaces, stacks, towers, reactors and heat exchangers of all kinds, drums of all shapes and forms, pumps and compressors, and motive equipment. These are separated from the *facilities* which would include all materials and labor involved in foundations, piping, instrumentation, structures, insulation, and electrical apparatus. We handle *electrical* units including switchgear, starters and the like, separately. Our estimate then analyzes the *material* side of each of these subheadings, and the equivalent amount of *labor* required to put them into place. All of these items included are what I'm sure you refer to as *capital goods.*

After this is totalled up there are office costs which include the home office charges for drafting, engineering, purchasing, and accounting. Then we have to add certain insurances and construction costs. Biggest of construction costs will normally be one's tools. Sundries, which come under the heading of construction supplies, include welding rods, oil, grease, toilet paper, paper cups, etc. The estimate also includes field supervision, field office personnel. *General overhead,* which includes *profit,* is tagged on to the end of the estimate.

MODERATOR: Arnold (Allen), would you expand on how you actually estimate these things, showing us a method which gives the highest degree of accuracy?

ALLEN: To begin, you have to decide on the degree of accuracy you want to achieve in your estimate. That is limited normally by the amount of time you wish to put into it. If you're interested in an approximation for budget purposes you can make what is known as an equipment estimate and ratio it up to a final cost.

In preparing an estimate of that type, we (Lummus) develop the cost of equipment involved which will be roughly 50% of the capital cost.

In other words, if you take your equipment and labor associated with installing that equipment that is approximately 50% of the total cost of the materials section of the estimate from foundations on through piping, instrumentation, electrical and so on.

SMITH: What type of processing unit are you talking about? Or do you find such ratioing applies to practically any type of unit?

ALLEN: It's most accurately used with refinery rather than with chemical units, particularly if a chemical unit has highly specialized equipment or a high alloy to carbon steel material ratio.

MODERATOR: Arnold, I'd like to have you get on to how you (Lummus) arrive at the proposal type of estimate, one on which you have to stand or fall.

ALLEN: A contractor stakes his whole existence on the proposal estimate. To begin with, the customer should be able to present what he wants, clearly and definitely.

Generally, the customer's request arrives in one of two forms. It will either come in as a completed design or as performance specifications. In either case you end up with a finalized design, represented by flow sheet, plot plan, elevation drawings, specifications and equipment schedules. I think they pretty well define what the project is. Once those are developed, the preliminary engineering phase of this job is over and the job goes from an engineering section to an estimating section. The estimators would start from the layout, from the specifications, and from the equipment required. They would develop foundation and structural requirements. We evolve rudimentary drawings from which we can estimate yardage of concrete, tonnage of steel, as starting points. Similarly, from the flow sheet and plot plan the piping section would begin to make layout drawings. From that we take off quantities and sizes of pipes. Valves are normally counted off the flow sheet, fittings and flanges have to be estimated.

MODERATOR: You make actual takeoffs to get such an estimate. What

we're really seeking, however, is to learn whether it's done by that method of actual takeoff or establishment of rather complete bills and materials or whether by use of experience factors based on methods you've practiced. You were saying you would never use a factor type of estimate for proposals if you had to stand or fall on it.

ALLEN: I'd prefer not to be in that position.

MODERATOR: Let's ask J. O. Adams of Dow if his organization follows estimating practices similar to those of the contractor just described.

ADAMS: In Dow's Texas Division, the estimator is a member of the cost control section of the Engineering Dept. The estimating group is responsible for three types of estimates. We call the first of these an "approximate" estimate. This estimate is normally made by applying a factor to the estimated value of process equipment required for the project. Other means of estimating approximate costs include application of unit prices to production quantities and scaling similar plants up or down by using the familiar 0.6 exponential factor. Management uses this approximate estimate for economic justification of a plant as well as for preliminary authorization requests for money for engineering and purchase of long-delivery equipment. We are expected to produce this estimate in a maximum of four hours and management expects an accuracy of ±20%. Information available for this estimate is normally an index flow sheet of process equipment and a rough sketch of plant layout.

MODERATOR: One of the complaints of our (Monsanto) top management is that we haven't defined the accuracy of our estimates to their satisfaction. Once defined, even if plus or minus 20%, they'll accept it if they know that. They don't like to think it's within one range and then have it come out to another. On the other hand they don't want it implied that it is ± 5% when it is really only a ± 20, or they don't want to think it's ± 20 if it's ± 50. Our problem then has been one of attempting to define for management what that accuracy is.

ADAMS: The second type of estimate is one we call a "preliminary" estimate. It is requested at a later stage of the project when additional information, such as planning drawings or some detailed drawings, is available. If the project engineer has any reason to suspect the cost of the job might be exceeding the approximate estimate during the course of engineering, he requests this type of estimate. It is a combination of the approximate estimate on portions of the job not clearly defined and material take-off and pricing on all detailed portions. Its accuracy is normally in the range of ±10%.

Arnold's description would better fit a project for which the contractor does the engineering in addition to estimating. Right, Arnold?

ALLEN: I mentioned the two usual cases. One was to receive full design; the other nothing but skeleton information from which we (Lummus) would prepare the design. Dow usually submits a design, attaching two score drawings—or even 200 drawings.

ADAMS: Our third type of estimate is called a "bidder's" estimate and is used by management to compare with the construction contractor's bid. It is based on complete material take-off and pricing of completed engineering drawings and specifications and is usually within ±5% of the *low* bidder among the contractors.

MODERATOR: Mr. Houlgrave, would you tell us about American Oil?

HOULGRAVE: First we (Amoco) have what we call "horseback" estimates. And then, of course, firm estimates when we're actually asking for money to do the job. The horseback ones would usually be for orientation purposes and take anywhere from 5 minutes to maybe half day for a $5 million job. In no case do we go into really detailed estimating. We expect our firm estimates to be within 10%. We have a project engineering department in which all estimating is done by whichever project engineer happens to become responsible for the job. We have no Estimating Department as such.

We keep records on equipment such as pumps, compressors, furnaces—all items that might go into a refining unit. We also keep records on all purchases so as to provide information as to what we paid for different types of equipment. These records are set up on different bases. For instance, pressure vessels will be on cost/lb., exchangers cost/sq.ft. I've never been able to find a correlation on pumps. Some compressors can be correlated on the basis of cost/horsepower. We don't often have to go back to an equipment manufacturer for prices, as we have enough data of our own.

For making an estimate say for a complete refining unit or part of a unit, we would list up all of the major items such as furnaces, exchangers, pressure vessels, pumps and compressors. Then we'd apply a percentage (experience) factor and get the total cost. We have breakdowns on all the units at Texas City. As crude as this procedure may seem, it's surprising how accurate we come out. We seldom miss by 10%.

Most of them come close to the lowest bid if it's a contract job.

ALLEN: It's my understanding that when you do make your ratio estimate

L. to r., Young (Humble), Bach (Monsanto), Smith (Carbide), and Street (Diamond).

your ratio is a "sliding ratio" and it's of value only in comparison to a similar unit.

HOULGRAVE: We (Amoco) do this, but with judgment. We'll take a look at the unit to see if it calls for alloy pipes, larger lines, or a disproportionate amount of pressure vessels and furnaces, and apply correction factors. We can do that and come out close.

MODERATOR: Chili (Houlgrave) what's your experience on small estimates? Suppose you were trying to estimate something in the $20 to $50 thousand range? Can you be as accurate using those methods?

HOULGRAVE: On a small job such as a pipe line to put in or some similar job, we'll take off material and add up labor factors we know. It's the labor factor that will vary.

YOUNG: Do you have the privilege of supplementing your appropriation when the scope changes?

HOULGRAVE: We do, by obtaining approval.

MODERATOR: Is that a standard practice around the table? It is with Monsanto.

SMITH: It's true of Carbide.

MODERATOR: Just for the record everyone around the table says they have that latitude.

ALLEN: I'd like to comment that if the contractor runs over his estimate he's normally digging into his own pocket.

ADAMS: We (Dow) don't run over our estimates unless there's a change in scope or a change after construction begins. Our work is done mostly on lump sum bids. There's little chance of going over in those circumstances. We normally include a contingency for field changes and the project engineer is responsible any time that money is running short. He does something about it.

MODERATOR: I think that may be true more or less of all of us again.

YOUNG: Is it true that Dow doesn't do any of its mechanical work in that it's all contracted out? Do you have a maintenance force?

ADAMS: Maintenance force, yes. No construction force.

HOULGRAVE: Practically all of this work of ours (Amoco) was done by our own forces, some was contracted out. We estimate the cost of contracted jobs before we go out to a contractor for bids.

ADAMS: Your project is authorized prior to bid, is that right?

HOULGRAVE: Almost without exception.

BACH: We (Monsanto) have a maintenance force at Monsanto which does minor construction but, for example, we don't have any construction pipe fitters or construction pipe fitter supervisors. We have a small force at Texas City which can supervise a construction job but would have to engage a contractor for a larger job. Does Humble have a construction supervision force which may serve in effect as the prime contractor?

YOUNG: Humble has some 2,500 people in its Mechanical Department of which 400 are engaged in new construction.

L. to r., Allen (Lummus), Adams (Dow), and Houlgrave (Amoco).

MODERATOR: Does Dow have a construction supervision force which would serve as your own prime contractor?

ADAMS: Yes. We (Dow) have a Construction Dept. to supervise. The prime contractor takes over the job and runs it under their direction.

MODERATOR: To see that Dow's specifications and standards are met?

ADAMS: Yes.

MODERATOR: Mr. Houlgrave, American Oil doesn't have construction forces, does it?

HOULGRAVE: Well yes, we (Amoco) do. We have pretty close to 1,000 men in the mechanical department and they work both as maintenance and construction people, principally maintenance. Turnaround takes quite a few men.

MODERATOR: Here again is that business of turnaround that was established in the petroleum industry and which has been picked up by the type of chemical operations typical of the Gulf Coast area.

ALLEN: Chili, is the use of your (Amoco's) own construction or maintenance personnel limited by any certain dollar value of project?

HOULGRAVE: Limited by manpower.

ALLEN: If you had a million-dollar project and you figured you were staffed to handle it, you would not go out for bids on it, correct?

HOULGRAVE: That's right.

MODERATOR: Is that true of Humble, Mr. Young?

YOUNG: Somewhat the same.

MODERATOR: What kind of estimates do you deal with?

YOUNG: Humble has two forms of estimate. First, orientation estimate—we term it a tentative estimate—and it has an accuracy of plus and minus 20%. That particular estimate is based on somewhat meager process information and mechanical design. We add automatically 20% (which has been arrived at over a number of years through experience) to this as a contingency item. If the estimate comes out $10,000 we add $2,000, or 20%. The estimate is then published as being $12,000 with an accuracy of ± 20%. We have found that this 20% is usually needed as a result of the process designer adding some instruments or something like that in the final design which usually increases the cost by 20%.

MODERATOR: You're talking everybody's language.

YOUNG: Our (Humble's) formal estimate is one which we develop in detail. We require a completed flowsheet and a plot plan that have been agreed upon by our technical, mechanical, and process groups. Then we prepare the estimate by making an accurate material takeoff, equipment takeoff, getting quotations, and then estimating the labor based to a great extent on past performances on material-labor ratios where such information is available. Other times we concentrate on mechanical performance and development of manpower schedules in order to arrive at the cost. As to accuracy, over the past 10 years the pluses and minuses pretty much balance out to the extent that we haven't missed the total more than 5% during any particular budget year. Factors have come in for a lot of attention at Humble for the reason that we're often called upon by management to tell them what a new plant of unique design is going to cost. We have, based on units that we've constructed and information furnished by contractors, developed factors that vary from 2.3 for a pipe still to 5.3 for a complicated low temperature crystallization unit. Use of factors to determine plant cost requires a tremendous amount of judgment and should not be resorted to except where time is a limitation.

BACH: Our estimates at Monsanto for the most part are done on a factored basis. We have the same problem that Mr. Young mentioned. We realize that we can get awfully good estimates if we get the right factor. We never do have any drawings.

MODERATOR: That work was done in a very uncertain period when some of that money was put in for escalation, some of which didn't actually develop. Ray (Smith) could we hear about Carbide's practices?

SMITH: We (Carbide) have a rather small central engineering group at Texas City which handles quite a few of the $100 thousand jobs, but not many in the million class. The larger projects are designed by our Central Engineering Group in South Charleston, W. Va. We use the project system similar to American Oil's. The project engineer makes his own estimate and is responsible for the project from start to finish. We make two different types of estimates. The preliminary project estimate merely obtains approval to proceed with design and closer estimate for the project. These are accurate normally within 20 to 25%. However, budget request estimates are expected to be within 10%. As to work forces, we use the contractor's force as the surgepot in the maintenance work load. The maintenance forces do not work on new construction, but may work on capital projects of replacement nature or intimately connected with existing facilities. I'd like to ask Mr. Allen how his firm determines its unit labor cost?

ALLEN: Unit labor costs are one of the big headaches of estimating. They are estimated a number of ways. We (Lummus) maintain a file of return costs which I think is the heart of any estimating group's work. We develop costs in many ways. We have unit costs, for instance, a range for putting in mass foundations, another range for minor foundations. These costs are expressed in \$/cu.yd. We have other unit costs for erecting steel, with range varying with the type and position. Heavy steel, low elevation, would have one range; handrails, platforms and ladders 80 or 100 ft. in the air would run more per ton installed. At best, your estimate varies all over the map depending on when you receive materials, the particular superintendent in charge and the project engineer the customer has in charge.

SMITH: Is your (Lummus) piping done on a tonnage basis? Or per foot basis?

ALLEN: Different ways for different areas. For instance, putting pipe in racks in long straight runs, you might approach the matter in terms of \$/ft. of a certain size. The usual process piping, which is any number of weird shapes and in assorted lanes, has to be in either \$/piece or \$/ton. To erect fabricated steel the cost is from $75 to $250 a ton. Platforming hand rails (light stuff) might run as much as $200/ton, relatively high in the structure—above the 50-ft. level we'll say. Putting up the main columns of the structure up to 60 or 75 feet might run only $75/ton. The number of pieces handled is so much smaller that the unit cost is smaller. Pipe installed at grade does not go into the same cost as pipe installed 100 feet up in the air even though it's the same piece of pipe physically. You could produce 100 charts that might cover the subject, but then you'd have to decide which one to use.

SMITH: We see so many articles published that show graphs on \$/ft. for pipe of various sizes. However, their use appears limited because it depends, as Arnold points out, on the locality, the labor market at that time, the circumstances under which you're working, whether it's a revision or new construction, whether it's crowded condition or open condition. On the other hand, distillation columns, tanks, pumps, compressors, and similar equipment can be estimated from charts for preliminary proposal type of estimates of 20 to 25% accuracy, providing you factor the pipe, instrumentation, steel, concrete and similar items.

ALLEN: I am in full agreement with that. As far as our experience in estimating is concerned, charts are of little value. They're grossly misleading, except for the budget type estimate.

HOULGRAVE: I'd like to concur with that heartily. To change the subject, I'd like to mention that we take into consideration whether contractors are full up on work or whether it is the lean season. It can make a lot of difference in the estimate.

L. to r., Alexander (Monsanto), Allen (Lummus), Adams (Dow), and Houlgrave (Amoco).

ALLEN: I think what you find is that the information which lends itself easiest to graphing on charts is that which you need least. If you want to know the cost of a pump you don't have to estimate it. You can call the man who will sell you one and he'll tell you.

STREET: I don't believe that the use of charts is generally advocated for firm estimates. We (Diamond) never used them as such but they do come in very handy in arriving at a budget figure. It can tell you whether you want to pursue the matter any further. That's the general picture, I think, of the way most people use charts. They rarely ever make a firm bid on it. I don't think Lummus ever does a thing like that.

L. to r., Allen (Lummus), Adams (Dow), Houlgrave (Amoco) hidden, and Young (Humble).

ALLEN: I agree with that. Also, that a chart serves a much more useful purpose for an operating company than for a contracting company.

MODERATOR: John (Street), how do you do your estimating?

STREET: We (Diamond) have a Central Engineering Department at Cleveland and an Engineering Department at the Deer Park plant. In the Project Engineering Group at Deer Park each engineer is responsible for an entire project. He does the estimating, the design, and almost everything, but he does have people who can give him help in specialties like electrical, construction, or instrumentation. We hope to get out of that and establish an estimating branch, because we think it will be more efficient to have one man who can take the time to compile data. The way we presently compile our information is probably similar to the way Lummus does. We have an account system and make our estimates on the accounts systems and we try to keep the construction costs on that. We can use that in our plant and come up with some very good estimates based on costs of existing units. When we get into a large unit, we generally go through detailed engineering before we get an appropriation approved for the construction of that unit. We do use ratios as a means of arriving at a rough cost to see if the project is feasible and to decide whether to devote so much money to engineering, and so on. With the detailed estimates we get within 10%.

Ours is primarily an electro-chemical plant and we actually can't use any of the published figures and charts because everything we have is different from the usual run-of-the-mill. Even the cooling water doesn't seem to want to run in steel pipe. So these ratios of equipment to labor with things like that just fall down.

MODERATOR: How do you define small work?

STREET: Small work to us (Diamond) is a project of $50,000 or less. Now, our Deer Park plant engineering staff doesn't do too many jobs over $100,000 since our main engineering office in Cleveland does a great part of those. They have developed all sorts of estimating data which they use and we use to a certain extent. But having the data at hand from actual construction is a more accurate source of information. Incidentally, we do have a construction force after a fashion. We have a construction and maintenance department and we sometimes use contract men for construction and sometimes we use part of our maintenance force. In estimating our cost sometimes we have to try to foresee who's going to do the work.

SMITH: I hear all these fellows about the table here telling how close they come on estimates and what reliable data they derive. I'd like to ask John Street here, how do you get a unit piping cost from your plant accounting group?

STREET: Well, we (Diamond) set up a construction accounting system where we try to segregate all the items that go into the cost of a construction project and even try to break it down into different units. For instance, if we're making an addition that has several different units we code those so they can be broken down. In that way you can, knowing the general description, differentiate between piping in long runs, that which is racked, and some that's up in the structure, and such things as that.

SMITH: Can you get those items from the costs that are returned to you, and are they reliable? Or do you get a general, over-all piping cost? What I'm getting at is whether operating organizations can get accurate return cost data when they mix construction men in with maintenance men, shifting from one job to another, working one day on one job and then being pulled off and then go back on to it again. How in the world does one keep from getting bad figures and shooting them right back into estimates?

ADAMS: We (Dow) don't attempt to get cost information from such jobs. On the other hand, none of the contractors have been particularly anxious to hand back any figures on how much it costs. But as long as you're working cost-plus or have your own construction force it should be fairly easy to accumulate reliable information.

HOULGRAVE: Foundations can hardly be tied down on the basis of return costs. On the other hand, pipelines are broken down in our accounting pro-

cedure by material. We (Amoco) publish a bill of material for each line. This is checked against actual jobs and if they check out fairly close we've got a pretty good idea that the line was worked out properly. In those cases where they don't check out, we go back and see how the labor was misapplied. I'd like to ask a question of Arnold. What kind of variations in labor have you found on large jobs? 10%, 20%, 30%? Suppose you had built several cat crackers or other large units of a particular type, what range of variation have you found in total labor between those units?

ALLEN: I would expect that in building identical units within a reasonable period of time of each other you could expect as much as 25-30% difference in the labor costs.

HOULGRAVE: Then the labor cost is in itself what, 25 or 35% of your total cost?

ALLEN: The labor cost would be roughly 25% of the over-all material and labor cost not including field and office construction.

ADAMS: Direct labor?

ALLEN: Yes.

ADAMS: I'd like to make clear that our (Dow's) engineering department is not actually on a project basis. It's a sort of mixture, in that we have a project group, but we also have groups of specialists. We have a design group, an administrative group, and a control group. In the control group we have about seven estimators who do nothing but estimating. Those estimates consist of our detailed bidders' estimates and cost comparisons on different projects that are under way. The project engineer is responsible for a job, but he assigns the job to the various design groups within the organization.

One of our big problems is determining the amount of money required for services for a specific plant.

MODERATOR: Would you define "services," Mr. Adams?

ADAMS: Utilities, such as electric, gas, water, air, etc. Services and general facilities in the plant amount to a very significant figure. Cost to Lummus is just the cost of the new installation; the cost to Dow is the cost of the new installation plus all the services and facilities that have to be constructed to go with it.

ALLEN: Doesn't this get down to the fact that what we are talking about is not one but two estimates? You prepared one estimate for a process unit. You're going to have to service it so that you analyze your overall utility balances. If you have a surplus of steam then the addition to that estimate is the cost of running a steam line from your last branch takeoff. If you don't have a surplus of steam you have to put in a new boiler, then that has to be estimated as a separate part of the job.

MODERATOR: That's correct. The contractor's bid is only a part of your total appropriation request, therefore the contractor's limit is usually to the battery limit. He has nothing to do with the services part of the estimate generally.

ALLEN: In a proposal we (Lummus) will in almost every case list for you the utilities required by the plant. You can then estimate what it takes to bring them to you. I'd like to mention one aspect of estimating which is often overlooked. Contractors' designs often affect the number of operating people it will take to run the unit. Contractor A's bid may be high because he has a good deal more instrumentation, but the units' running costs are sufficiently low to far offset that additional first cost. That may or may not be taken into account when the bids are analyzed.

MODERATOR: A good point. It's extremely difficult to handle, though, because there are too many other factors entering into it. Such as your union contract. However, we (Monsanto) almost never pay any attention to operating cost estimates by a contractor.

ALLEN: I think it's more generally applied to refinery than chemical plant practice.

YOUNG: Wayne (Alexander), do you mean that in not paying any attention to operating costs, you were referring only to labor requirements?

MODERATOR: No, I would include all factors.

YOUNG: I was wondering if J. O. (Adams) had in mind utility requirements?

ADAMS: No, this problem is normally resolved at an earlier stage.

L. to r., Alexander (Monsanto), and Adams (Dow).

MODERATOR: When the information is available our (Monsanto's) engineers estimate utility needs exactly; they use the delta-t on heat exchangers to tabulate water-flow and establish water consumption. You protect yourself on cooling tower capacity, pumping capacity, and your water supply. The contractor is as guilty as we of using only theoretical knowledge without due consideration of experience factors.

HOULGRAVE: We (Amoco) go a little further than that usually. We usually tell the contractor how to set up the utilities.

MODERATOR: We (Monsanto) tell them how to set them up but we don't tell them the quantity.

YOUNG: We give them the value of the utilities to Humble and then let them make their own economic balance. Getting back to basic procedures, Humble has two estimates. First, the immediate cost, then the long range cost types. The latter includes utility portions. In other words if you had a unit that's going to consume 100,000 lbs. of high pressure steam and take 1/3 of the output of a boiler, then 1/3 of the investment in that boiler is shown as long range investment cost.

MODERATOR: It seems that different members of management may have different figures they look for. Some are more responsive to a return on new capital. Others don't pay any attention to that but do to return on total fixed capital after taxes. Let's discuss this business of cost indexes. What do they accomplish?

YOUNG: Indexes, like the factors used in ratio estimates, are tools of the estimator's trade. As construction cost records are usually compiled over a period of years with rising costs, it is convenient to have a rapid method of escalating yesterday's cost record to present-day conditions. For this purpose we (Humble) use correction factors evolved from the indexes published in Engineering News Record, remembering that these indexes are based on all types of construction work and hence, like the factors used in ratio estimating, must be used with judgement.

MODERATOR: Mr. Adams, do you use any of the Indexes?

L. to r., Allen (Lummus), and Adams (Dow).

ADAMS: I have used most of them. We (Dow) probably use the ENR index more than any of the others.

MODERATOR: Do you (Dow) use indexes to predict future trends?

ADAMS: Yes.

HOULGRAVE: Several years ago we (Amoco) started an index of our own by taking typical refinery equipment and keeping track of the prices and installation costs of these items.

BACH: One use that we (Monsanto) make of the indexes other than trending future costs is the resurrecting of old estimates and old equipment cost.

MODERATOR: Mr. Adams, do you use indexes other than ENR?

ADAMS: We actually did some checking on equipment costs over a period of time and found that Marshall-Stevens was the most accurate for equipment. Others in our company like the Bureau of Labor equipment index. However, the ENR Construction Index seems best for the overall picture.

BACH: We plot ENR, Marshall-Stevens and Nelson. Nelson runs above ENR and Stevens below ENR. So with the ENR index in the middle we use it. There ought to be an index designed specifically for chemical plants.

STREET: We (Diamond) use projections of ENR index, and with our judgment we arrive at certain contingency which we list as a certain restricted reserve. Management can either take what we show or they can alter it according to their views.

MODERATOR: Is that general practice here?

YOUNG: No, we (Humble) use contingencies but never set them out separately in the estimate unless management requests it. Under agreement with our management our estimates do not contain provisions for escalation that might take place after the date of the estimate.

HOULGRAVE: Basically, any project that goes through has to have an economic justification. That is based on some future sales estimate. The decision is made on weighing the present cost of plant versus the anticipated earnings of the future. If you justify your project now, you can be fairly sure it's still going to be good two or three years from now.

ADAMS: I wonder if you could open up another subject for discussion, the effect of mechanical specifications on the estimated cost of the job. For instance, one company will build a unit at a certain price. Another may build the same unit of the same capacity to produce the same product, but because specifications differ, it won't be bid at the same amount of money.

MODERATOR: You're talking about the effect of companies' different mechanical standards, aren't you?

ADAMS: Yes. Our (Dow's) standards have undergone a considerable amount of revision for that very reason. They tied the contractor down too closely to get good economical work from him. Our present policy is to write a specification which we think will get the type of equipment or project that we want and still leave the contractor as much leeway to carry on his business, his purchasing, etc., to his best advantage.

HOULGRAVE: The major oil companies developed their own specifications. Doesn't the contractor building a unit try to get the thing done at the minimum cost? On the other hand, the company is trying to build a unit to operate efficiently over a period of years. So you have a contrast there. Also, it's hard to change once you've set up standards. It's quite a job to keep your specifications up to where you're getting the most equipment for the least money in the long range picture.

STREET: By our doing the actual process design and using our standards we (Diamond) relieve the contractor of that problem. When we do get an outside engineer to do the design for us, we don't ever ask him to bid competitively.

YOUNG: Arnold, do you think that companies waste a lot of money by submitting a fixed specification for you to bid on?

ALLEN: I think that in general, operating company specifications tend, by their very nature, to defeat themselves after a while. The book of standards gets so thick that (as Chili has pointed out) there's a great inertia involved in getting anything changed. I'm not saying this is a problem that lies solely within the operating companies. We in our own company (Lummus) have had specifications which we consider vastly overdesigned, and have been revising them, bringing them down to where they meet code.

. . . . . preparation of OPERATING COST ESTIMATES

Operating cost estimate along with capital cost estimate are the two basic tools necessary to economic decisions. This paper is an attempt to define the operating cost estimate—the elements of cost that go to make it up—and to add some commentary that may be of value. This basic tool is so fundamental to making intelligent decisions that a clear definition and understanding are mandatory and cannot be taken for granted.

E. Roy Sweet | Singmaster & Breyer

An economic analysis of a project normally is made several times during the course of the project. When the chemistry of the process has been established in laboratory- and bench-scale work, a preliminary economic analysis is made. During the course of the pilot plant program an economic analysis will be made at least once again, and as the chemistry of the process becomes translated into the technology and the glass beaker becomes the stainless steel reactor, the possible accuracy of the operating cost estimate increases. Assuming that the project has passed all its tests by the various levels of management, approval of a board of directors is normally required for final action. The operating cost estimate which is submitted to the board is the one which is most accurate.

Bases for Estimate

In the actual preparation of the estimate the costs may be presented on an annual basis, a daily basis, or, most commonly, a unit-of-product basis. There is a fundamental difference between the annual basis and the latter two; the annual must of necessity take into account the plant on-stream time, while the daily and the unit-of-product bases do not consider this factor.

Types of Cost

The production of any chemical normally involves at least three and possibly four general types of costs: costs for the use of money, costs for the use of materials, costs for the use of labor, and costs for the use of know how. This is not the conventional method of categorizing the various costs, but sometimes it is a useful one. A more conventional method of allocating charges, and one that is normally used in the preparation of a formal cost estimate, includes direct operating costs; plant-burden, or indirect, costs; fixed costs; and miscellaneous costs.

DIRECT OPERATING COSTS

For the production of a conventional chemical product the direct manufacturing costs are those which require the greatest time and most careful consideration to estimate. Surprisingly enough, however, they may or may not be the largest item of cost of the four categories just mentioned. It will depend to some extent on the nature of the product. In chemical plants with a low sales-capital ratio, such as is normally found in the heavy and basic industrial chemicals, fixed costs may actually be a larger percentage of the total than are direct operating costs.

Raw Materials

The raw material requirements, which are based on material-balance calculations, include all chemicals directly consumed in the process and other chemicals that may be used for such purposes as scrubbing of waste and vent gases or neutralization of waste streams. It is important, particularly in the case of heavy and industrial chemicals, to charge the chemicals into the process not at the quoted sales price, but at the delivered price. If, for example, one were receiving sulfuric acid by rail, the freight charge for that delivery must also be included in the price of the sulfuric acid. If the particular plant in question is an autonomous one-product plant, then unloading charges such as labor and pumping need not be included as part of the chemical cost but may be shown as a labor and a utility cost. In a multiple-product plant it may be difficult to disassociate the labor and pumping charges for a particular unit plant from the total plant consumption of sulfuric acid. In such cases it is customary to use as the cost of the acid the freight and delivery charges and unloading costs combined with the f.o.b. price of the acid, to give, in effect, a delivered price to the battery limits of the particular unit plant.

When the chemical being consumed is also produced within a multiproduct plant, it is good accounting practice to charge that chemical into the process at its normal market value. The sulfuric acid operation is then allowed to show a profit just as if sales of the acid to outside companies were being consummated. If the acid were charged into the process at cost, then no profit would be obtained from the acid plant, and the new-product plant would have to bear the double burden of a profit for itself as well as the acid plant.

Catalysts

The method of calculating a charge for catalysts consumed in process is similar to the general technique employed for depreciation of capital assets. In an ammonia synthesis plant, for example, where a medium-pressure synthesis loop is used, the life of the catalyst may be taken at anywhere from 4 to 8 years. Consequently, the original cost of the catalyst could be divided by the estimated ammonia output during these 4 to 8 years. Some companies have the policy of capitalizing first charges of catalysts, particularly long-life catalysts such as the one just mentioned. Some companies go so far as to capitalize first charge of all chemicals. Under these conditions the actual charge for the catalysts and the chemicals will occur in a depreciation and amortization account rather than in a raw materials account. There are some catalysts whose life is essentially equal to the life of the physical plant itself, and it is recommended that in these cases the cost of the catalyst be carried as a capital charge, while any cleaning, purification, or regeneration be carried as a maintenance charge.

Direct Operating Labor

Direct operating labor includes all personnel engaged in the direct production of the products up to and including working foremen. In continuous chemical plant operations with a 168-hour week schedule, care must be taken to provide four shifts to man the operation. It is surprising to see the number of estimates for continuous processing where only three men are provided for a shift job instead of the required four. Furthermore, each man is paid

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on the basis of a 365-day year although the product may be made for only 350, 330, or perhaps even 300 days/year. Where operating labor is a significant portion of the operating cost, for example in such products as low-bulk, high-value chemicals, this can lead to a serious error.

Supervisory Labor

The dollars associated with this direct operating labor are gross wages and should exclude at this time pay-roll overheads. Also excluded from this charge are supervisory personnel, from, perhaps, the level of foreman on through to that of the departmental head or the production manager. The amount of supervision associated with operating labor varies widely depending on the nature of the product and may range from as low as 3 or 4% of operating labor to as high as 40%. The latter case occurred in the manufacture of a high-priced pharmaceutical where a graduate engineer or chemist operated as the shift foreman for each process step, which required perhaps two to three men a shift.

Maintenance

Plant maintenance, another item of direct operating costs, can be divided into three major categories of material, labor, and supervision. Some judgment must be exercised in determining whether a maintenance operation is legitimately that or a capital expenditure. For the preparation of operating cost estimates such a situation arises infrequently, but nevertheless it does arise. For example, in high temperature furnacing one normally has the problem of replacing the refractories in the furnace at frequent intervals, in some cases as frequently as every 3 months. In my experience I have found just as many companies allocating these costs to a capital account rather than to a maintenance account.

With new technology it is difficult to estimate maintenance costs, and the conventional way is to express them as a percentage of capital investment. There is a justification for this where technology is well understood, but in new technology this method can be regarded as little better than an intelligent guess—in some cases, not so intelligent. For plants dealing with non-corrosive materials and with relatively mild operating conditions, maintenance costs as a percentage of initial capital investment of about 3 to 6% are fairly common; for plants where extremely high temperatures, or high pressures or strongly corrosive conditions are incurred, total maintenance charges, including materials, labor, and supervision, may run as high as 20 to 25%/year. One must also take into account whether the general materials of construction are inexpensive ones, such as mild carbon steel, or whether they are expensive, such as stainless steel. Where mild steel is normally used throughout the plant, a good rule of thumb is that one dollar of mild steel maintenance material will require one dollar of maintenance labor and supervision. Where a plant is up in the high alloy range, such as the 18-8 stainless steels, two to three dollars of maintenance materials will require one dollar of maintenance labor and supervision.

Still other factors to take into account in attempting to estimate maintenance are the size of the individual pieces of process equipment in relation to the total plant, and the ratio in size and in cost between process equipment and auxiliary facilities, such as buildings, utilities, distribution systems, and so forth. Where the cost of individual pieces of equipment is large with respect to the total plant cost, the maintenance required on that piece of equipment is a smaller percentage of the cost of that equipment than is the maintenance required on an inexpensive pump. In plants of this type, therefore, one must factor down the maintenance cost. Normally, the process installation requires substantially more maintenance than such facilities as buildings and underground utilities. The maintenance cost for these latter types may run as low as a fraction of 1% up to 2 or 3% of their original capital cost. Where complications of this type are incurred in the preparation of an estimate, it is recommended that the maintenance charge be divided into categories such as battery-limit process plants, buildings, underground distribution, and so forth. This categorization is justified only where an attempt is being made to prepare a fairly rigorous operating cost estimate.

A final point in assigning a maintenance charge is the issue of changing costs. This issue is more general than maintenance costs alone. Prices tend to increase, and consequently while the maintenance cost of a year-old plant may bear a correlation with the original capital cost of the plant, this will not be true of the maintenance costs in 10 or 15 years. Also, as the equipment grows older, the repair bills have the unpleasant habit of getting larger and larger. Consequently, in prognosticating maintenance costs, one should take into account the increasing price of labor and the increasing amount of repair that will have to be made for the plant in general. This same argument could logically be applied to other elements of cost.

Operating Supplies

It has been common practice to indicate operating supplies, such as oils and greases, wiping cloths, soaps and detergents, as an item separate from maintenance, and this is consistently the practice in the preparation of standard unit costs when the plant is actually in production. The contribution of these supplies to the over-all manufacturing cost is minor and they might best be included in the maintenance charge. For a plant with normal maintenance charges, that is to say, somewhere around 4 to 6%, a quick rule-of-thumb figure for operating supplies would be 10 to 20% of the maintenance charges, but inasmuch as operating supplies bear little relationship to the cost of the process equipment *per se*, this 10 to 20% figure may drop down to 5 to 10% in the case of high alloy equipment or equipment with high maintenance charges.

Utilities

The utilities consumed within a process include such items as electrical power, steam, water, gas, and so forth. If the plant to be built is part of an existing plant, it is likely that standard costs for such utilities as steam per thousand pounds or cooling water per thousand gallons are available; these unit prices can be inserted directly into the operating cost estimate. If, however, the plant is to be an autonomous one, then a standard cost must be calculated for each of these utility items in order to apply them to the process unit. In some cases, rather than apply a unit price per thousand pounds of steam, one calculates as part of the plant raw materials the amount of fuel consumed per unit of product and the amount of labor and maintenance required and includes these in the total operating cost. In this way no unit price is established, but the total operating costs are nevertheless determined. In general, it is more advisable to calculate a unit price for each utility so that process alternates may be evaluated—at least insofar as utilities consumption is concerned. This is not quite as simple as it sounds, inasmuch as the unit price for the utility may vary with the total demand for the utility. A good example of this is the economic comparison between the removal of carbon dioxide from synthesis gas by high-pressure water absorption, and an ethanolamine scrubbing system. In the former case it is necessary to compress synthesis gas to approximately 300 lb./sq. in. The carbon dioxide is absorbed in the water and released when the water pressure is reduced. In the ethanolamine scrubbing system low-pressure synthesis gas is scrubbed with an aqueous amine solution, the carbon dioxide forms a compound with the amine, and the ethanolamine is regenerated by steam stripping.

In either case the power or the steam consumed has an appreciable effect on the size of the power plant and on the size of the steam plant. This effect is large enough to influence the cost of either the power or the steam, and so one can get into a vicious circle in a calculation of this type; a rigorous answer requires a trial-and-error solution.

Pay-roll Overheads

There is some tendency to charge pay-roll overhead or pay-roll burden into the direct operating costs, although some companies put it into the indirect costs. Be that as it may, it is an item of cost which should not be overlooked. The pay-roll overhead or burden includes such items of cost to the employer as Federal old-age benefit payments, state unemployment and disability payments, vacation wages, group-insurance programs, profit-participation programs, and the like, and the general tendency of these pay-roll overheads or fringe benefits is to increase. When no specific figure is available for this overhead, 20% of the sum of operating labor, direct supervision, and maintenance labor and supervision may be used, but many companies have pay-roll overheads in excess of the 20% figure, and every effort should be made to ascertain the particular union contractual agreements for a given chemical company and other company policies on vacations, pensions, and the like.

INDIRECT COSTS

The list of indirect costs include the following: first-aid and medical services, safety engineering, fire protection, general plant security, general engineering and maintenance other than the process plant itself, stores, property, salvage, automotive transportation, railroad transportation, janitorial service and other sanitary services, travel, moving and living expenses, utility requirements for nonoperating areas, laboratory analyses, Workmen's Compensation, property-damage and public-liability insurance, general administrative and office overhead. These items of cost involve the use of material as well as labor, and where labor is involved care must once again be taken to include the pay-roll overhead for this labor. One must also take care that certain costs are not incurred twice; for example, if a separate expense is reported for receiving, then the cost of a chemical (as previously discussed) used in the process should not include that receiving cost.

The actual indirect costs can vary widely and depend upon many factors, some of which have been previously mentioned. In the construction of an autonomous plant wherein all the services just mentioned must be included, it is possible that the indirect costs may be as high as 100% of the estimated direct costs of operating labor, supervision, maintenance, and supplies. If, however, this new plant were to be one small producing unit in a multiproduct installation, the overheads or indirect costs might run as low as 15 to 20%, although this would be an abnormally low figure. In an autonomous plant it is suggested that a figure be used for indirect costs which is 50% of the direct labor, supervision, maintenance, and operating supplies.

New Techniques for COST ESTIMATION

FIXED COSTS

The fixed costs include depreciation and amortization; patents; royalties and licensing arrangements; state, local, and county taxes; and the interest on working capital. The interest on working capital should always be included in the operating cost, inasmuch as the dollar value of the working capital would normally be held in bonds or mortgages in the company's treasury and would actually be earning money. This rate may vary from 3 to 6 or even 7% of the dollars involved in the working-capital requirement.

State, local, and county taxes vary widely and it has been the author's practice to use a figure of 1% of the

SAMPLE FORM
FOR TYPICAL OPERATING COST ESTIMATE

	Units per Unit of Product	Cost Per Unit	Cost per Unit of Product	
I—DIRECT OPERATING COSTS				
A. Raw Materials				
1. Chemicals	xxx	$xx	$xxx	
2. Catalysts	xxx	xx	xxx	
B. Operation & Labor				
1. Direct	xxx	xx	xxx	
2. Supervisory	xxx	xx	xxx	
C. Maintenance				
1. Materials	xxx	xx	xxx	
2. Labor	xxx	xx	xxx	
3. Supervision	xxx	xx	xxx	
D. Operating Supplies	xxx	xx	xxx	
E. Utilities				
1. Steam	xxx	xx	xxx	
2. Water	xxx	xx	xxx	
3. Electricity	xxx	xx	xxx	
F. Payroll Overheads	xxx	xx	xxx	
Subtotal I				$xxx
II—INDIRECT OPERATING COSTS				
A. First Aid	xxx	xx	xxx	
B. Safety Engineering	xxx	xx	xxx	
C. Salvage	xxx	xx	xxx	
Subtotal II				$xxx

	Units per Unit of Product	Cost Per Unit	Cost Per Unit of Product	
III—FIXED COSTS				
A. Depreciation	xxx	$xx	$xxx	
B. Insurance	xxx	xx	xxx	
C. Taxes (Other than Income Taxes)	xxx	xx	xxx	
D. Patents & Royalties (If on a lump sum basis)	xxx	xx	xxx	
E. Interest				
1. Construction Capital	xxx	xx	xxx	
2. Working Capital	xxx	xx	xxx	
Subtotal III				$xxx
IV—MISCELLANEOUS COSTS				
A. Research	xxx	xx	xxx	
B. Sales	xxx	xx	xxx	
C. Distribution	xxx	xx	xxx	
D. Administrative	xxx	xx	xxx	
Subtotal IV				$xxx
V—TOTAL I-IV				$xxxx
Contingency ——% V				xxxx
		Total		$xxxx

construction capital requirement for estimating these taxes. In one situation, however, the company involved pays approximately 80% of the total taxes in a given county, and a figure of almost 3% of the capital investment is therefore being allocated for such taxes.

Various forms of insurance must be included for protection against fire, explosion, and tornado; for product liability; and for the almost numberless types of protection that are needed. These insurance rates depend to a considerable extent on (1) the nature of the process and (2) the nature of the product. For example, the manufacture of nonhazardous chemicals in nonhazardous processing areas will permit a relatively low insurance rate in comparison with that for plants using large quantities of such solvents as carbon disulfide and diethyl ether. A figure of 1% of the construction capital requirement has been found adequate for low-risk plants, but as much as 3 and even 5% is needed where the risk is substantially higher.

Patent, royalty, and license payments are of two types, "paid up" or "running," or a combination of both. In the case of the paid-up type, the cost is amortized over the period of the legal life of the arrangement. In the case of the running royalty the payment is made on the basis of the number of units produced. These payments may be on a sliding scale, of which account must be taken. Unless one is aware of specific requirements, no attempt should be made to add royalty dollars to the cost.

There are several techniques for calculating depreciation and amortization, and the government has aided in the general confusion by permitting some new methods in its recent revision of the tax law. Among the several choices available are the following techniques:

1. Straight-line depreciation.
2. Unit of production.
3. Double declining balance.
4. Sum of the year's digits.
5. Fast amortization.
6. Combination of items 1 and 3.

Inasmuch as detailed discussion of depreciation or amortization is not within the scope of this paper, the only pertinent point that will be made here has to do with the necessity of considering two calculations for depreciation and amortization. One of them is the allowable accounting figure which by precedent or law the Bureau of Internal Revenue will permit. The other one is the calculation based upon the estimated true life of the plant. On occasion these two figures are in substantial agreement, but more often than not they are not, and a specific point should be made concerning the method employed.

MISCELLANEOUS COSTS

In addition to the costs already discussed, there are four other costs which have not yet been mentioned but which have material effect. They are the research costs, the sales costs, the distributive costs, and the executive or administrative costs.

The research costs depend upon the nature of the product; for example, if one were considering the installation of a sulfuric acid plant he would argue that the technology is so well established that no research expenditure is required. If, however, a new product were being considered, then the research expenditure might be a substantial item. Where the process has gone through a development program and the research expenditure has been considerable, some thought must be given to whether or not this previous research expenditure should be charged against either the capital or operating expenses of this plant. This is a subject of substantial confusion, and there is no intent to enter into any further discussion of it here.

In the same fashion that research expenditures vary considerably, so may sales expenses. In products where the individual sales are large with contractual arrangements between top officials of the company and the customers, the sales expense can be minor; in certain of the highly competitive items, such as nail polish, cosmetics, or soaps, the sales and advertising expenditure is very substantial and can, in unusual cases, even exceed cost of manufacturing. In the sale of some chemicals the manufacturer must defray part or all of the freight charges. In addition to these costs the leasing of tank cars or gondola cars must also be included as part of the distributive costs. Nor must one overlook the packaging costs, which become significant for small packages such as proprietary or ethical pharmaceuticals, foods, and particularly cosmetics.

The executive-office overhead is another item of cost which is normally carried separately and which includes a *prorata* portion of executive salaries.

On these four items of cost the variation of expenditure is so great that it would be rash to indicate here even a range of figures.

TOTAL COST

When one has added together all these various items of cost, he must, as befits every good engineer, add in the element of contingency, being careful not to compound a felony by piling a contingency upon a contingency. The magnitude of a contingency depends upon the reliability of the estimate. For example, with an established technology and known company policies for overheads, etc., and in an attempt to make a rigorous estimate, such a contingency should not exceed 5%. With new technology and with unknown or unestablished company policies, such a contingency could be as high as 25%.

In addition to preparing an operating cost estimate based upon operating at design capacity, it is necessary to prepare similar estimates for lower operating rates. It is the rare chemical plant which runs at 100% of capacity year in and year out. Consequently, there must be an appreciation of the change in manufacturing costs as the operating rate is decreased. In almost every case a decrease in the operational rate will result in an increase in the unit-production cost, particularly when fixed costs are taken into account. The fixed costs remain constant or essentially constant, but fixed cost per reduced unit of product made is going to increase. This also holds true of some of the other charges such as operating labor. Some of the operating costs, such as raw materials and possibly utilities, will be reduced almost proportionately, and some of them, such as maintenance charges, will be reduced at a rate less than proportional. The preparation of an operating cost estimate at reduced plant capacity requires the exercise of judgment just as the initial cost estimate does.

In this paper presentation of rigorous quantitative method of preparing an operating cost estimate has been avoided. What is written here does not fit into a formula for an automatic-processing machine. No intelligently prepared operating cost estimate can result by putting factors into a machine. The preparation of such estimates requires the exercise of judgment, and an adherence to a formula or to various percentage factors can only indicate to the initiated that the estimate has been prepared in a mechanical fashion without a clear and complete understanding of the components of such estimates. The best way to prepare an intelligent operating cost estimate is to prepare lots of them, to find out mistakes, and to avoid repeating them in subsequent estimates.

Presented at A.I.Ch.E. New York Section meeting.

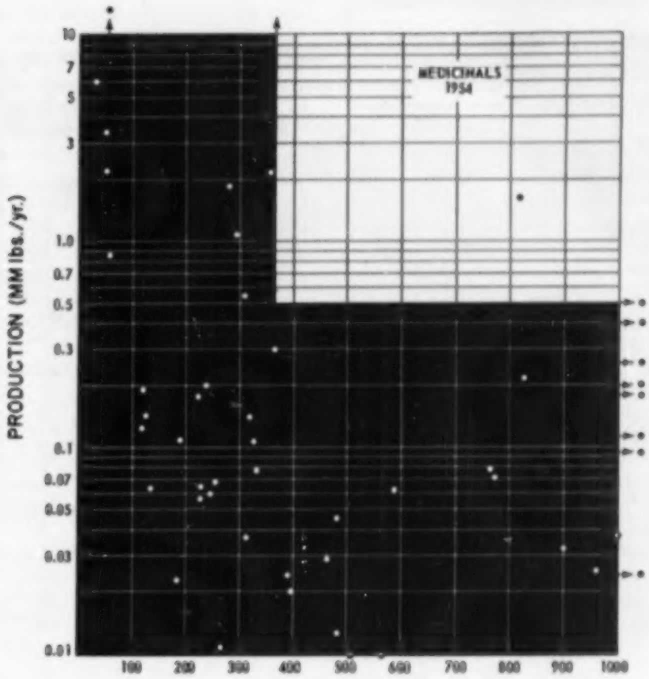

Fig. 1.

An important type of estimate vital to both the manufacturing and marketing phases of the chemical industry involves the cost at which a given product must sell in order to be successful in the competitive market. One of the methods of preparing such an estimate is through the use of the Exclusion Chart, which is described with appropriate examples in this paper.

THE EXCLUSION CHART

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Many discussions have taken place relating primarily to the various techniques utilized in preparing an estimate of the cost of manufacturing a given material. Such an estimate is usually based on an evaluation of the cost of each step in the process, a summation of which provides the desired estimate of the cost of manufacture.

Another type of estimate involves the cost at which a product must sell if it is to enjoy commercial success in the competitive market. This paper is concerned with one of the methods by which such an estimate can be prepared.

There are many procedures used by the market researcher to gather the needed information. Common practice covers a detailed evaluation of the volume to be consumed by each use at varying price levels. Combination of these end-use figures produces the estimate of the price (cost) at various consumption levels. The pay-off is when the cost and plant size estimates of the engineer and the price (cost) and market estimates of the market researcher meet at a price and production level which will provide an adequate return on the investment.

Time, too often, does not allow more than a few hours to determine the price which must be placed on a product if it is to *sell*. Recently a company had *four hours* to make such an estimate. Needless to say this was done on a "best-efforts" basis only.

One method which has been developed to obtain such estimates utilizes a series of charts which have been dubbed exclusion charts. Unless a product for a given type of use can be provided for less than a certain price, (e.g., \$3.60/lb. for medicinals in 1954), it is *excluded* from enjoying a market above 500,000 lb./yr. (see Figure 1)

There is no known theoretical explanation of this relationship; it is entirely empirical. In an empirical relationship, such proof as there is rests entirely upon whether the relationship exists for a large number of end-use classifications. The accompanying figures would seem to indicate that the exclusion charts can be utilized to provide an estimate of the price (cost) for which a product can sell.

Medicinal Products

Figure 1 contains data utilized for 1954 taken from United States Tariff

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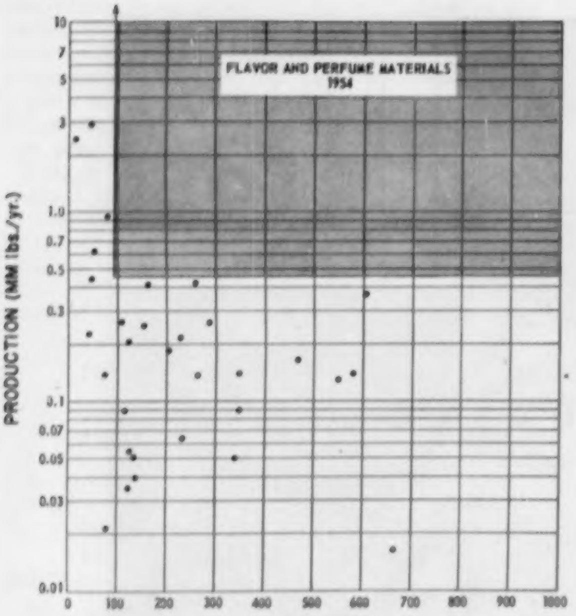


Fig. 2.

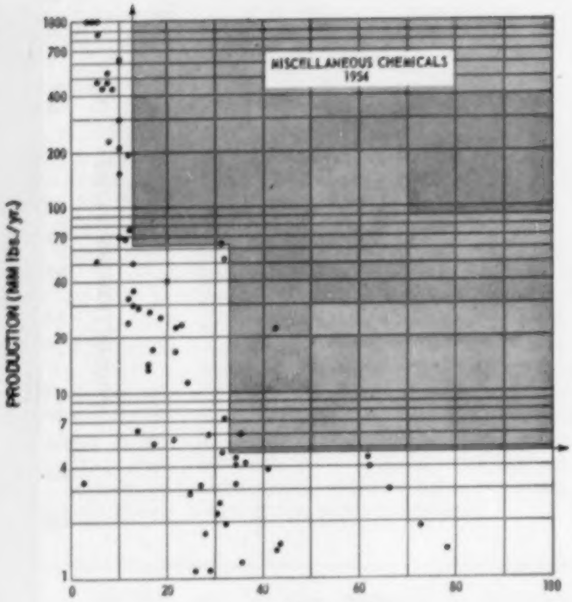


Fig. 3.

Commission statistics. The abscissa represents the average sales price of a particular medicinal. The ordinate represents the volume sold. This figure is the basis for the previous statement that in 1955 no medicinal which sold for more than $3.60 lb./yr. had a production volume of more than 500,000 lb./yr.

The small arrows ending in dots on Figure 1 represent a product which sold for either a higher price or in a higher volume than indicated on either scale. In other words, those points at the right of the chart represent medicinal products, generally antibiotics and vitamins, whose sales price was above $10.00/lb.; the point ending in a dot above the figure represents a medicinal product (aspirin) with a sales volume above 10,000,000 lb./yr. The single point in the exclusion area represents the vitamin, ascorbic acid.

Again one comes back to the problem of the time required to gather the necessary price-volume-end-use data, if the check is to be a fast one. A handy source of such information is the data, compiled by a broad end-use category found in the Annual Report of the United States Tariff Commission on "Production and Sales of Organic Chemicals." (*1*)

A similar figure for medicinals for 1952 has shown a limit on sales of 400,000 lb./yr. unless the price is below $4.00/lb.; for 1949, 200,000 lb./yr. and $4.50/lb.; for 1947, 175,000 lb./yr. and $3.00/lb. These data indicate that any estimate of a market for more than 500,000 lb./yr. of a medicinal at a price above $3.50-$4.00 is suspect. The market researcher should recheck his estimates if the data fall within the exclusion area and the research and engineering departments should take a sharp look at their estimated production cost. The increased sales volume — from 175,000 lb. in 1947 to 500,000 lb. in 1954—is almost wholly due to the increase in sales of high unit value antibiotics and vitamins.

Flavor and Perfume

The exclusion area for flavor and perfume materials is shown in Figure 2. The limits are an annual production of 500,000 lb. and a price of about $1.00/lb. For preceding years these figures are:

Year	Annual Poundage	Price $/lb.
1947	200,000	3.00
1949	110,000	2.70
1952	400,000	1.70

Miscellaneous Chemicals

Figure 3 actually shows two different price-volume exclusion limits. To attain a production volume more than 60,000-000 lb./yr., the sales price of the product must be less than 13¢/lb. Sales volumes up to 60,000,000 lb./yr. are often obtained for items priced up to 33¢/lb.

One point shown at 160,000,000 lb./yr. at 23¢/lb. should be disregarded since it represents a multiproduct classification (cyclic lubricating oil additives).

Year	Annual Poundage	Price $/lb.
1947	6,800,000	0.16
1949	9,000,000	0.14
1952	5,800,000	0.19
1954	4,500,000	0.35

Pesticides and Agricultural Chemicals

Exclusion limits on pesticides and agricultural chemicals are given in Figure 4.

Year	Annual Poundage	Price $/lb.
1947	....	....
1949	....	....
1952	960,000	0.50
1954	400,000	0.60

Plastics and Resins

Insufficient data are available on the more costly plastic resinous materials (Figure 5) to enable an estimate to be made of a poundage limit. The two points well past the limit indicated are for plastics with special applications, polyvinyl butyral for safety glass inner layer and silicones.

Year	Annual Poundage	Price $/lb.
1947	....	0.52
1949	....	0.38
1952	2,000,000	0.41
1954	....	0.49

Plasticizers

The two points over the limit indicated (Figure 6) are sebacate esters. They are not only used for plasticizers but have other uses as well, such as for

the synthetic lubricants for the latest gas turbine engines for jet aircraft. Thus the economy-price-volume relationship for sebacates is not necessarily the same as that commonly associated with plasticizers.

Year	Annual Poundage	Price $/lb.
1947	......	0.42
1949	......	0.42
1952	......	0.43
1954	......	0.46

Perhaps of even greater interest is the correlation of the limiting price of plasticizers and of plastics.

Rubber Processing Chemicals

Figure 7, showing rubber processing chemicals, is of questionable value because of the apparent lack of correlation. Further, the number of points is insufficient for the indicated purpose.

Year	Annual Poundage	Price $/lb.
1947	6,300,000	0.42
1949	4,500,000	0.58
1952	3,200,000	0.55
1954	5,000,000	0.52

Cyclic Intermediates

There are two points on Figure 8 for cyclic intermediates which fall within the exclusion area. The one point represents salicylic acid, the other nonyl phenol.

By far the largest portion of the production of salicylic acid is used for the manufacture of aspirin, a medicinal. Therefore, its price-volume relationship should more nearly conform to that of a medicinal than to that for cyclic intermediates. It does.

There is some error in the price 52¢/lb., listed by Tariff for nonyl phenol. The current tank car price is only 24¢/lb., delivered according to several producer and consumer contacts. At this price nonyl phenol is moved outside the exclusion area.

Year	Annual Poundage	Price $/lb.
1947	1,900,000	0.23
1949	2,500,000	0.25
1952	2,500,000	0.26
1954	4,000,000	0.21

Surface Active Agents

Most of the products which have pushed the price limit up from the earlier 20-28¢/lb. to the present 40¢/lb. derived either from ethylene oxide or from various amines. Here is an example of the changing price (cost) pattern that can and does occur for a specific end-use category. (Figure 9.)

Year	Annual Poundage	Price $/lb.
1947	2,700,000	0.20
1949	1,000,000	0.28
1952	1,600,000	0.41
1954	1,300,000	0.40

Tariff reports production and sales data on three other end-use categories: dyes, lakes and toners and elastomers.

There is an insufficient number of different elastomers produced and thus inadequate data are reported to provide a figure with any pattern.

The other two categories, namely dyes, and lakes and toners, present still another problem. A plot for dyestuffs does not show an exclusion area of the type shown on the preceding figures. Rather it presents a picture somewhat akin to that shown in Figure 10. There are points quite equally distributed under line A.

This is not surprising when the structure of the dyestuff industry is examined. Dyes are used in relatively small quantities by many different consumers to achieve highly individual effects—colors. This combination spells high unit price and low production poundage for most products.

Further, in dye production, intermediates are produced first, usually on a relatively large scale, but each intermediate can be converted into any number of colorants. One step is sufficient for some colors whereas others require many. The one-step product is relatively inexpensive, whether manufacture is on a small or a large scale. Thus cost of manufacturing is not the direct function of production volume encoun-

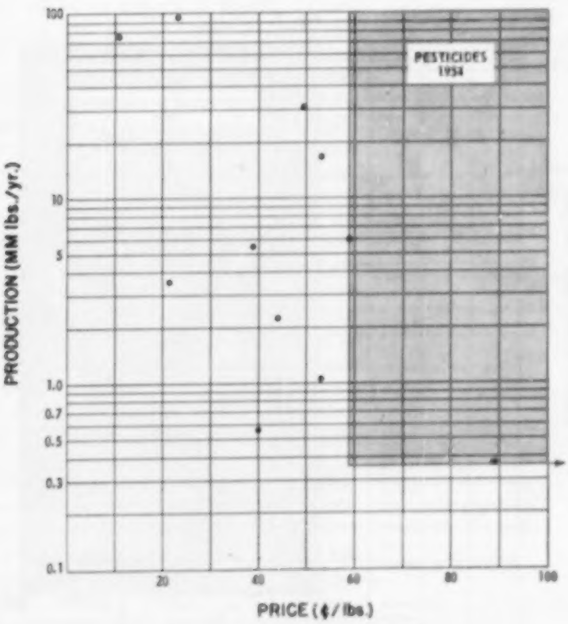


Fig. 4.

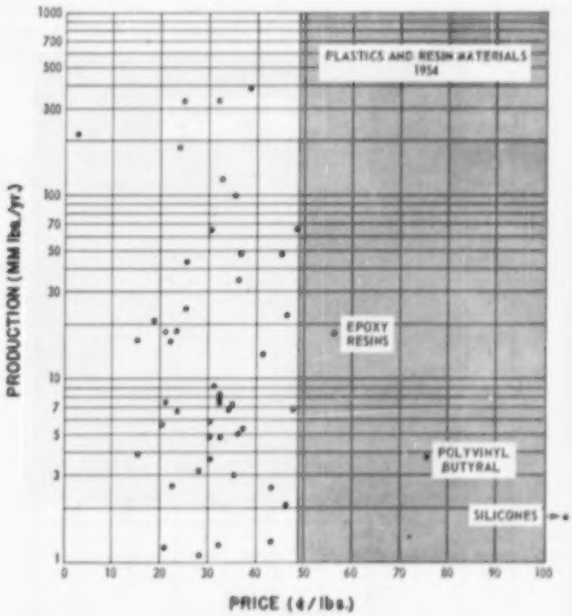


Fig. 5.

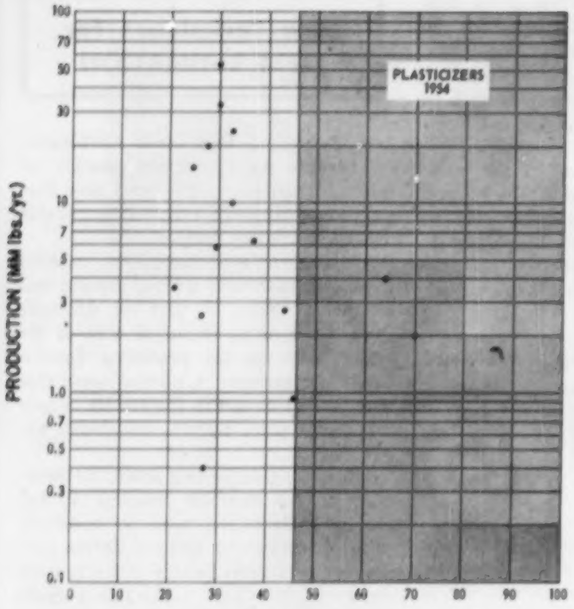


Fig. 6.

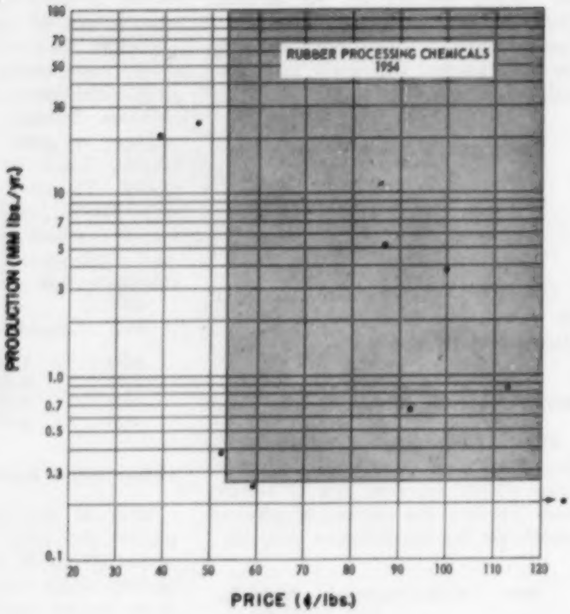


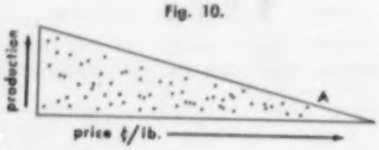
Fig. 7.

tered in most other end-use categories.

There is a great deal of judgment involved in picking the proper line. If an attempt is made to exclude all points from the exclusion area, an incorrect result will be obtained. Further, it must be remembered that properties not otherwise available can often command a high price as well as a suitable production volume. The polyvinyl butyral inner layer for automobile safety glass is a good example. Its price is some 30¢/lb. higher than the exclusion price shown in the chart for plastics and resins.

A curve could be fitted to the points

Fig. 10.



plotted, perhaps more clearly than the exclusion lines that are utilized. However, a curve cannot be described simply in the manner of the exclusion lines. Thus comparisons are more difficult to make.

Literature Cited

1. Annual Reports U. S. Tariff Commission—"Production and Sales of Organic Chemicals."

Fig. 8.

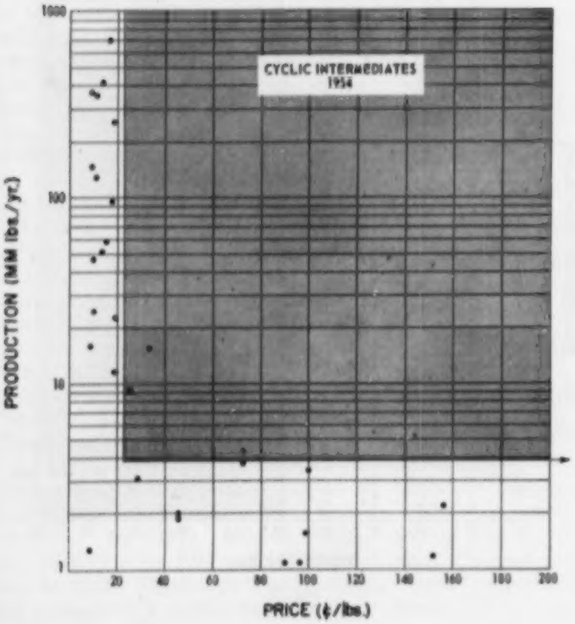
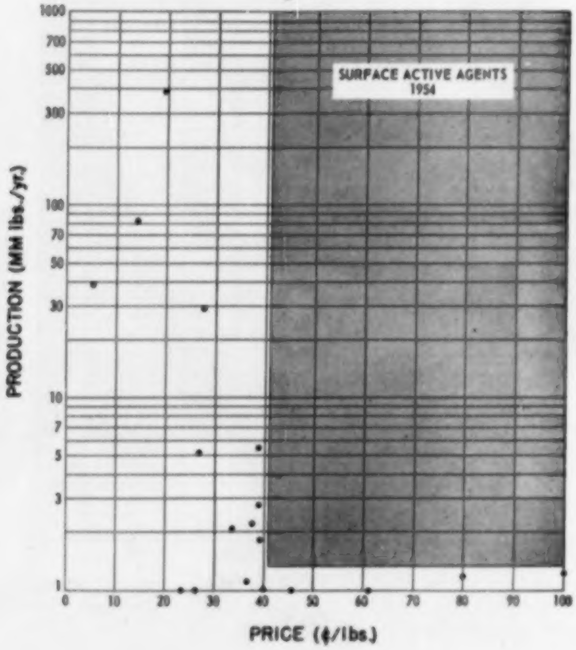


Fig. 9.



The importance of complete and accurate CAPITAL COST ESTIMATES

When you are confronted with the problem of recommending or opposing a proposed process industries project, as many chemical engineers are, have you ever wondered about the apparent discrepancies between all-too-typical economic evaluations and actual profit histories? The purpose of this paper is to analyze these discrepancies.

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Brea Chemicals, Inc., Los Angeles, Calif.*

Economic justification for a new process industries project is usually based on an equation of anticipated profit with the estimated capital-investment requirements. Regardless of the formula used to relate profit and capital investment and of the criteria used for judging the adequacy of profits, a sound economic justification cannot be prepared unless the total capital-investment cost estimates are both complete and accurate.

Almost everyone has encountered economic evaluations which indicate payout times of two to three years or show a net return after taxes of 25 to 35% of the capital investment. In contrast to this type of economic evaluation, Table 1 shows the 1954 corporate profits of some of the more successful chemical companies. The returns on total assets of the selected companies vary from a low of 4.7 to a high of 18.0%. Shown are the total assets of each company and its corresponding total net income after income taxes, both in terms of dollars and expressed as a percentage of total assets. Total assets are defined as plant properties less depreciation and plus working capital. The group of companies selected has average total assets of $636,000,000 and an average net income of $60,000,000, or, expressed as a percentage, returns 9.5% on the total invested capital. If depreciation is added back to the assets, the average total investment of the selected companies is $896,000,000 and the average net profit expressed as a percentage equals 6¾%. If it is further taken into account that the net income is made up of 1954 dollars and a large part of the assets is in dollars which are worth a great deal more, there would be an even lower average net return.

While higher than average returns on capital investment are possible, and frequently realized, exceptionally high returns are most frequently accompanied by inherent competitive advantages or greater risks. If an economic evaluation of a process industries project in a competitive field indicates an unusually high return, a critical reexamination of capital cost estimates is called for. The factor which has the greatest effect on estimated profitability is the estimate of total capital-investment requirements.

Economic evaluations are based all too often on the estimated battery-limits cost of the process units built to minimum operable standards of construction and safety. To this, many other items of cost must be added before a new process project can reach the stage of successful and profitable operation.

Elements of Capital Investment Estimate

The checklist on the next page shows the primary elements of capital investment in process industries projects: cost of plant facilities, working capital required, and preprofit expenses. Each of these will be explained in considerably greater detail.

PLANT FACILITIES

First the elements of plant facilities cost will be considered. Whenever a new plant is to be constructed, there are many costs besides the bare cost of minimum operable process units. The checklist shows the elements of plant facilities cost — the cost of a prepared site, the cost of buildings, the cost of utilities plants, the cost of storage facilities, the cost of auxiliaries, the cost of outside piping, the cost of the process units, and finally other capitalized costs which are often forgotten. All these costs will usually total between 130 and 150% of the cost of the battery-limits process units built to minimum standards. A figure of 145% is quite typical.

When a new project is considered, statements such as those following are often heard: "We don't have to build a new office building for this plant," or "Our boiler plant is quite adequate to provide the additional steam load." But sooner or later the investment in such facilities must be made, and for the next project it may be far out of reasonable proportions. There is actually no such thing as a "free ride" on existing facilities. For a process industries project to be sound, it must be able to support its fair share of the capital investment in other than process facilities. Some

Table 1.—1954 Profits of Selected Chemical Companies

	TOTAL ASSETS	TOTAL NET INCOME	
	Millions of Dollars	Millions of Dollars	Per Cent of Assets
Du Pont *	1,337.1	240.3	18.0
Union Carbide	1,251.6	89.8	7.2
Dow	704.8	33.4	4.7
Allied	688.8	43.1	6.3
American Cyanamid	499.9	27.1	5.4
Monsanto	376.5	23.7	6.3
Hercules	135.2	14.1	10.5
Rohm & Haas	96.5	12.4	12.8
Averages	636.3	60.5	9.5

* Excludes G.M. stock.

* Mr. Tielrooy is Manager of Development.

A.I.Ch.E. • SPECIAL FEATURE

CHECKLIST

Items Essential to a Capital Estimate for a Process Industries Project

• PLANT FACILITIES

COST OF PREPARED SITE
- Land
- Access to Site
  - Raw material, product, utility pipe lines
  - Sewer lines
  - Access road and railroad spur
  - Right-of-way
- Site Preparation
  - Site grading and drainage
  - Roads and parking areas
  - Chemical, storm, and sanitary sewers
  - Fire protection system
  - Railroad tracks
  - Street lighting
  - Surface treatment (oiling, graveling)
  - Fencing

COST OF BUILDINGS
- Office building
- Maintenance shops
- Operating materials warehouse
- Guard house
- Dispensary
- Safety department building
- Cafeteria or lunch building
- Garage or carport
- Plant control laboratory
- Technical service laboratory
- Utilities control house
- Shipping office
- Change house
- Maintenance materials warehouse

COST OF UTILITIES PLANTS
- Electric power substations
- Water wells and clarification facilities
- Water storage
- Water treating facilities
- Plant air compressors
- Instrument air compressors and driers
- Fuel blending and storage facilities
- Steam boilers
- Cooling water tower & pumping system
- Utility chemicals receiving and storage

COST OF STORAGE FACILITIES
- Raw materials storage
- In-process materials storage
- Product storage
- Process chemicals storage

COST OF AUXILIARY FACILITIES
- Blowdown systems and flare stack
- Incinerator
- Chemical sewage treating facilities
- Effluent water treating facilities
- Compressor oil recovery facilities
- Communications systems
- Emergency power generation
- Railroad scale
- Truck scale
- Landscaping
- Loading racks

COST OF PIPING OUTSIDE OF PROCESS UNITS
- Raw materials to process units
- Products from process units
- Materials between process units
- Raw water
- Potable water
- Treated water
- Condensate distribution
- Condensate collection
- Plant air
- Instrument air
- High pressure steam
- Medium pressure steam
- Low pressure steam
- Process chemicals
- Effluent stream collection
- Cooling water supply
- Cooling water return
- Fuel gas distribution
- Fuel oil distribution
- Fuel oil return collection
- By-product fuel collection

COST OF PROCESS UNITS
- Base cost—minimum operable unit
- Additives for owner preferences
  - Spare or stand-by equipment
  - Overdesign factors
  - Additions for improved safety
    - Fire protection equipment
    - Added ladders and stairways
    - Added platforms, access ways
    - Added lighting intensities
  - Additions for reduction of maintenance
  - Extra space between equipment
    - Added maintenance access roads
    - Added use of corrosion resistant material
    - Cranes, monorails, and hoists
    - Area paving
  - Additions for improved efficiency
  - Additions for reduction of pollution problems
  - Higher standards of construction

OTHER CAPITALIZED COSTS
- Capitalized cost of spare parts
- Escalation allowance—materials
- Escalation allowance—labor
- Permit acquisition costs
- Reengineering at owner's request
- Plant data books
- Plant operating manuals
- Insurance coverage during construction
- Trucks and automobiles
- Plant revisions during start-up
- Interest on construction monies
- Building furnishings

• WORKING CAPITAL

- Raw materials inventory
- In-process materials inventory
- Product inventory
- Operating materials inventory
- Process materials inventory
- Maintenance materials inventory
- Accounts receivables carried
- Minimum cash reserve (30 days' expenses)

• PRE-PROFIT EXPENSES

- Pre-operation expenses
- Plant start-up expenses
- Loss during initial period of operation before production and sales reach breakeven point

of the items which make up the cost of a plant are detailed below.

Cost of Prepared Site

The cost of a prepared site includes first the cost of land. Second is the cost of gaining access to the site: pipe lines, roads, railroad tracks, and right-of-ways. Third is basic site preparation, including grading and drainage, roads and parking areas, sewers, fire protection, railroad tracks, street lighting, surface treating, and fencing. All of these items of cost are incurred before process plant construction can even begin. The cost of a prepared site may vary from 2 to 10% of the cost of the process units. In the absence of specific site data, a figure of 4% is usually typical.

Cost of Buildings

Of the buildings which must often be constructed in conjunction with a process industries project, an office building is almost always required. Maintenance shops and warehouses for operating and maintenance materials are also necessary. Some of the other buildings are a guard house, a dispensary, a safety department building including space for fire fighting equipment, a cafeteria or lunch building for employees, a garage or carport for plant automobiles and trucks, a plant control laboratory, a technical service laboratory to work on customer problems, a utilities control house, shipping office, and an employee change house. To arrive at an accurate cost, it is best that actual requirements be specifically defined. The cost of buildings typically varies from 2 to 5% of the installed cost of the bare process units. For preliminary estimating purposes, in the absence of specific definition of needs, a figure of 3% will usually come close.

Cost of Utilities Plants

The commonly installed utilities plants required for a typical process industries project include electrical power substations and, in some special instances, even electric power generation facilities. Water wells and clarification facilities are often required. Water storage is almost a necessity in any plant. Water treating facilities to provide water of proper quality to the boilers, to the cooling towers, and sometimes to the process are required. Plant air compressors for utility use and instrument air compressors for instrument operation are almost always a necessity. In some plants, fuel blending and storage facilities are required either for gaseous fuels or for liquid fuels, or both. Steam boilers are generally necessary in a process plant. A cooling water tower is required in most plants unless an adequate supply of river water is available at hand, and

a pumping system is almost always necessary. Finally, there are utility chemicals receiving and storage facilities for such chemicals as sulfuric acid, caustic, salt, and other utility chemicals. The cost of utilities plants will vary with specific process requirements from 3 to 6% of process unit cost. A figure of 4% is typical.

Cost of Storage Facilities

Besides the utilities plants, there must be provided facilities for the storage of raw materials, in-process materials, final products, and process chemicals. To be accurate, the cost of storage facilities should be directly estimated for the specific project at hand since the variation can be wide—anywhere from 0 to 20% of the process unit cost. A figure of 10% is, however, quite typical.

Cost of Auxiliary Facilities

Some of the auxiliary facilities which are often necessary in a typical process plant include such things as blowdown systems and flare stacks; incinerator for the disposal of solid combustibles; treating facilities for chemical sewage and effluent water; recovery facilities for compressor oil; communications systems such as telephone, code call, intercom, and fire alarm system; emergency power generation facilities; railroad and truck scales for weighing of raw material receipts and product shipments; loading racks for trucks and railroad cars; and finally, landscaping for outside appearance. All of these items are often forgotten in the preparation of preliminary estimates. The cost of auxiliary facilities will normally run from ½ to 3% of the cost of process facilities. About 1% is a typical average cost.

Cost of Piping Outside of Process Units

Next to be taken into account is the cost of piping which connects all of the various auxiliary and nonprocess facilities with the process units themselves. Included must be all of the process piping to carry raw materials, products, and in-process materials. In addition to these, there may be as many as 18 utility lines connecting to each process section of the plant. The cost of such outside piping will normally run from 1 to 5% of the process unit costs and typically will average 3%.

Cost of Process Units

Finally comes the cost of the process units themselves. All too often, capital cost estimates are based on base cost estimates for a minimum operable unit. This might be compared to the factory delivery price of an automobile. However, before delivery is taken there are many almost-standard items which may add to the cost appreciably. Among the additives for owner preference which must be considered in arriving at the cost of the process unit are spare or stand-by equipment added for flexibility and reliability and also overdesign factors which are often added for ease of operation or to provide for ultimate expansion in productive capacity. Most large companies will make additions for improved safety including such items as added fire protection equipment, added ladders and stairways, added platforms and access ways, and improved lighting intensities. Many of the larger companies have found it expedient to spend additional capital to keep maintenance costs to a minimum. There are such items which add to the cost as extra space between equipment; added maintenance access roads; added use of corrosion resistant materials; cranes, monorails, and hoists; and adjacent area paving. There are also additions for improved process efficiency—this may include such items as added heat transfer surface for heat recovery, added trays in a distillation column to reduce product loss, or power recovery equipment. In many areas it becomes necessary to install additional equipment for the reduction of either air or water pollution problems. And, finally, many companies have higher general standards of construction than the minimum which would be required for an operable unit. To arrive at a sound estimate of the cost of process units, all of the items mentioned must be taken into account, based on knowledge of the company's standards and preferences. This may add anywhere from 0 to 20% to the base cost of the process unit. A minimum typical additive for owner preferences is 10% of the base cost of the process units.

Other Capitalized Costs

Finally, there are other capitalized costs which must be taken into account, some of which may be included in the contract price for a process plant, but often are not; therefore, specific cognizance must be taken of each of these items. They include the cost of spare parts, an escalation allowance for labor and materials during the period of construction, and the cost of permit acquisition. Often, there are engineering changes made during the job at owner's request which constitute an added cost. Before the plant is started into operation, plant data books and plant operating manuals must be prepared. The insurance coverage desired by many owners is higher than the minimum insurance coverage considered adequate by some construction contractors. The plant must also have the necessary trucks and automobiles, and the buildings to house them. Further, during the start-up of any process plant, there are almost always plant revisions necessary which cost money. In addition to all these items, interest on construction monies must be considered as a real cost. Construction interest should either be considered as an item of capital, or profitability and payout time should be calculated from when monies are first expended.

In addition to the foregoing principal items of plant capital investment, there are still two other major items of capital investment which are very necessary. One is the working capital and the other is what might be termed pre-profit expenses. The latter item is actually a portion of initial working capital requirements, but is seldom considered.

WORKING CAPITAL

Again, the checklist herewith shows the items which make up the working capital requirements of a business. These are first inventories—of raw materials, in-process materials, products, operating materials, process materials, and maintenance materials. Most of these can usually be estimated directly for a specific project.

The next item is accounts receivable. This is usually the major part of working capital and will vary considerably, depending upon the type of accounts served. Finally, a minimum cash reserve, usually equated to 30 days' expenses, is required as a cushion. Working capital requirements for a process industry vary from a minimum, usually not below 10% of annual sales, to a high figure which may be as high as 50% of annual sales. Typically, working capital requirements will amount to approximately 30% of annual sales.

PRE-PROFIT EXPENSES

Pre-profit expenses are another major item of capital which must be appropriated before the plant can start to make a profit. In actuality this is a portion of the working capital which must be provided at the beginning of the project. Pre-profit expenses consist of three items. First, the pre-operational expenses, which include the expenses of staff salaries, supplies and materials, the training of operators, and all other expenditures which must be made before start-up. The second item of cost con-

Table 2.—Elements of Product Cost

	Per Cent Per Year of Plant Cost		
MANUFACTURING	Low	High	Typical
Raw Materials / Process Materials / Purchased Utilities	(*)	(*)	(*)
Operating Labor, Materials, & Supervision	2.5	10.0	6.5
Maintenance Labor, Materials, & Supervision	2.5	8.0	4.5
Plant Administration & Overhead	2.0	5.0	3.5
Insurance, Tax, Interest, & Depreciation	8.0	15.0	10.5
Total Manufacturing	22.0	30.0	25.0
OTHER COST ELEMENTS			
Selling Expense / General Management Expense / Research & Development Expense	4.0	12.0	7.6
Income Taxes	6.0	23.0	9.4
Net Profit	5.0	20.0	8.0
TOTAL PRODUCT COST	45.0	60.0	50.0

(Excluding Raw Materials, Process Materials, and Utilities)

(*) Not Related to Plant Cost.

sists of the actual expenses during the start-up period. This often includes extraordinary expenses which cannot be predicted. Finally, the third item is the loss which may be experienced during the initial period of operation before production and sales reach the breakeven point. The net loss incurred, if any, depends entirely upon the complexity of the plant as well as the complexity of the job of selling the product. Often, in the process industries, a plant does not begin to operate at full capacity immediately, either owing to difficulties in the process plant itself or, more often, owing to the period of time necessary to penetrate the market successfully. During this period, before both sales and production reach what might be termed the breakeven point, a loss is frequently incurred.

The factors necessary to a complete capital cost estimate having been considered, the next step is to see how capital cost estimates can affect, first, estimates of manufacturing cost and, second, estimates of over-all profitability.

Estimates of Product Cost

Table 2 shows the principal elements of product cost. For any specific project, the first three items listed (raw materials, process materials, and purchased utilities) are obviously not related to the plant cost. Almost all of the other costs incurred in the manufacture of a product can be, as an approximation, related to plant investment. Even such items as operating labor, materials, and supervision; maintenance labor, materials, and supervision; and plant administration and overhead will, for a specific type of plant, bear a close relation to plant investment.

For typical process industry projects, the annual cost of manufacturing a product will run from 22 to 30% of the total cost of the plant, plus the cost of purchased raw materials, process materials, and utilities. Adding the other cost elements, which consist of selling expense, general management expense, research and development expense, income taxes, and expected return on investment, gives a total annual product cost which will be approximately 45 to 60% per year of the plant cost, plus the cost of raw materials, process materials, and purchased utilities. As an approximation, 50% per year of the capital investment in plant facilities will give a reasonable figure. Figures such as are shown on Table 2 must of course be used with care and discretion since they are not universally applicable to specific cases.

Profitability Estimate

Table 3 provides a comparison which shows the effect of capital estimate on profitability. The figures in Table 3 are completely synthetic, although any similarity to actual cases is definitely intentional. Case 1 shows a plant facilities estimate of $10,000,000 based on the cost of bare process units constructed to minimum standards. Often such a cost is used for the calculation of profitability. This shows a very handsome return on the investment of 23.5% per year after taxes. In Case 2, the $10,000,000 plant facilities cost for the same plant, but with all cost items included, becomes $14,500,000. Adding to this a working capital of $3,000,000 and a pre-profit expense of $1,000,000 gives a total capital investment of $18,500,000 instead of $10,000,000. Return on the investment, while still substantial, is 10% of the total investment as compared with 23.5%.

In summary, then, typical chemical process industries projects do not return profits on capital investment of 25 to 30% as are so often shown by economic evaluations. In order to improve the accuracy of economic evaluations and bring them closer to the realities of companies' balance sheets, it is absolutely necessary that the chemical engineer take into account every item of capital costs which must actually be incurred before a process project can become a profitable reality.

Table 3.—Effect of Capital Estimate on Profitability

	Case 1	Case 2
CAPITAL INVESTMENT		
Plant Facilities	$10,000,000	$14,500,000
Working Capital	....	3,000,000
Pre-Profit Expense	....	1,000,000
Total	$10,000,000	$18,500,000
ANNUAL SALES	$10,000,000	$10,000,000
ANNUAL EXPENSES		
Raw Materials / Process Materials / Purchased Utilities	$ 1,400,000	$ 1,400,000
Other Manufacturing Costs	2,500,000	3,600,000
Selling Expense / General Management Expense / Research & Development Expense	1,000,000	1,000,000
Income Taxes—54%	2,750,000	2,150,000
Total	$ 7,650,000	$ 8,150,000
ANNUAL NET INCOME	$ 2,350,000	$ 1,850,000
PERCENTAGE OF RETURN ON INVESTMENT	23.5%	10.0%

Presented at A.I.Ch.E. meeting, Los Angeles.

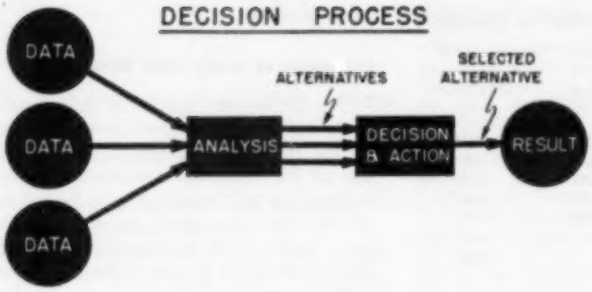

Fig. 1.

COST ESTIMATING AND DECISION MAKING

J. S. Hicks and L. R. Steffens | Socony Mobil Oil Company, Inc.

In the course of striving to reach whatever objective he has set for himself in business or in his personal affairs, a man compares the alternatives that are available in each situation and tries to pick the one that will take him farthest toward his objective. This selection of a course of action on the basis of a comparison of alternatives constitutes a decision. The objectives of this paper are (1) to present the details of this operation in mathematical form in order to facilitate a quantitative approach, (2) to define the function of cost estimates within this operation, and (3) to offer a procedure to serve as a guide to the kind of estimates that should be made.

The decision process can be illustrated by means of a simple flow diagram (Figure 1). First of all, data have to be collected, usually from several sources. Next, relationships between the data have to be worked out and the results of the possible courses of action estimated. The results of each course of action have to be reduced to some common basis, ordinarily dollars. This step of course includes estimation of all the costs involved. The organized data then point to the next step, in which one of the alternatives is chosen; that is, the decision is made. Action is included as part of this step, since a decision is not complete until action has been taken to implement it. Having selected an alternative, one then moves from prediction to actuality and must accept the outcome for better or for worse.

Alternatives

A generalized classification of the alternatives in any situation is as follows:

1. Continuation of the present operations.
2. Search for new methods of operation (research).
3. Improvement of the evaluation of a proposed new operation (better pilot plant data, market data, cost estimates, etc.).
4. Adoption of the proposed new operation.

Continuation of the present operation is usually the first alternative considered, and in any case is the reference plane for the evaluation of a proposed new operation. The second and third of these alternatives involve expenses (above those for continuing the present operation) that can be recovered only when finally a new operation is adopted that turns out to be a money-maker. It is an important management problem to decide how much effort should be put into research and into the evaluation of proposals. This paper will offer a guide for deciding how much effort to put into evaluation but will not attempt to answer the problem dealing with research.

Decision Criterion

One objective in business is maximization of profits. If it is assumed for simplification that this is the only objective, the evaluation of a proposed new operation can be expressed by means of the following equation:

$$P = I - C$$

$$\left(\begin{matrix}\text{Incremental}\\\text{Profit}\end{matrix} = \begin{matrix}\text{Incremental}\\\text{Income}\end{matrix} - \begin{matrix}\text{Incremental}\\\text{Cost}\end{matrix}\right)$$

The cost item must include all factors of future cost—labor, materials, any costs for development, and all capital charges. The last is defined as including return on investment at the minimum rate considered satisfactory. Then if P is a positive number, the new proposal will add to the company profits and should be adopted as a step toward maximizing company profits, but if P is a negative number it will be better to invest in something else.

Error Distribution

The foregoing statement of profits is incomplete. All the values are based on estimates of what may be expected to happen in the future, and the terms therefore should be labeled as *expected profit, expected income,* and *expected costs.* However, a more useful relationship can be obtained if one takes account of the uncertainty of the estimates by introducing an error term, usually denoted by ϵ. If this is done, the equation reads as follows:

$$P = E(I) - E(C) + \epsilon$$

$$\left(\text{Profit} = \begin{matrix}\text{Expected}\\\text{Income}\end{matrix} - \begin{matrix}\text{Expected}\\\text{Cost}\end{matrix} + \text{Error}\right)$$

The error term is not a single value but rather a distribution of values, one of which may be considered as being selected by some chance process for an individual evaluation. This error term actually results as an accumulation of the error introduced with all the items used in the evaluation—that is, the error in the yield data obtained from the laboratories, market research data, design information on which equipment cost estimates are based, and so on. Such an error term is part of any estimate whether it is stated explicitly or not. Actually it is an important part of the estimate and it should be stated explicitly to ensure that it will receive proper consideration.

Perhaps it is easier to think about the error distribution if one considers that he is playing a game in which, after he has made an estimate of the expected profit on a play and has decided whether or not to make the play, the banker throws dice to determine a value which is added to or perhaps subtracted from his estimate to determine the pay-off. If he knows the values on the faces of the dice the player can calculate the probability of each possible result and make his decisions accordingly. As he cannot see the dice

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Table 1.—Procedure for Obtaining Standard Deviation of Cost Estimating Procedure

Job	Estimate (a)	Actual cost (b)	Difference (b-a)	Difference adjusted for bias [b-(a+c)]	Square of adjusted difference $\div 10^8$
1	2,755,000	2,905,000	150,000	90,000	81
2	3,100,000	3,050,000	— 50,000	—110,000	121
3	2,500,000	2,720,000	220,000	160,000	256
4	2,850,000	2,780,000	— 70,000	—130,000	169
5	3,500,000	3,550,000	50,000	— 10,000	1
			300,000	0	628
Average difference (bias)*			60,000(c)	0	

Estimate of standard deviation † .... $= \sqrt{\frac{628}{4} \times 10^8} = 125{,}000$

* After bias has been determined, the estimating procedure should be corrected to minimize error in future estimates.

† It is necessary to consider whether the standard deviation should be calculated in dollars or in percentages and whether it applies to the cost estimating procedure alone or to the cost estimating procedure plus the definition of the job.

until after the bet is made, there is no way to ensure a profit on any individual play. However, he can follow a procedure which will maximize his winnings over a series of plays, and he will therefore apply this procedure to each play as it comes up. Similarly, he can expect to make a higher percentage of correct business decisions if he knows the distribution of the error term of his estimating procedure and takes it into account.

The important characteristics of the error distribution are (1) the average value (bias) and (2) some measure of the dispersion or scattering. The average of the error distribution can be obtained only by comparing estimated values with *true* values. Likewise, the measure of the scattering of results must be obtained by "looking at the record"—by comparing either (1) a series of pairs of estimates and true values or (2) a number of independent estimates of one particular value. These procedures are illustrated in Table 1.

The average value of the error distribution of an estimating procedure is simply the average value of the difference between the true value and the estimate. Perhaps the most useful basis for describing dispersion is the normal distribution, which is applicable to a great many kinds of experimental data. It probably will not be possible to prove that the normal distribution is applicable to a particular estimating procedure; however, unless there is evidence to the contrary, the normal distribution can be used as a working approximation. The important feature of the normal distribution is that most of the values are clustered around the average but a few are distributed well above and a few well below the average. The range over which the values are distributed can be measured in terms of the standard deviation, designed by σ.

The Cost of Cost Estimates

Obviously one will have a better chance of making correct decisions if his cost estimates or, more broadly, his evaluations have a small standard deviation. However, in general it costs more to obtain an estimate with a small standard deviation. As illustrated in Figure 2, the time involved in a cost estimate may be an important factor. Missed opportunities attributable to delays should properly be considered as part of the cost of extending the evaluation. It is always necessary, therefore, to balance the cost of reducing the standard deviation of the evaluation of a particular proposal against expected increase in profit.

Of course, no change made in one's evaluation will change the result obtained by accepting a proposal. Rather the opportunity for increasing profit comes from being able to sort out a series of proposals accurately; so one may accept most of the proposals that will result in a profit and can reject most of those that will result in a loss. The common-sense approach in this situation is to make a "screening" evaluation on each proposal first, then to make a more thorough evaluation on those proposals which merit it. The parallel common-sense approach in the field of quality control has been formalized in recent years; this formal approach, double or sequential sampling, is now widely used as a means of minimizing inspection costs. Similarly, the use of a logical basis for screening and re-evaluating proposals should lead in the long run to minimum costs and maximum profits.

Utilization of Background Information

One more point should be considered. It seems axiomatic that at each stage of the study of a proposal one should use all the information available to him in deciding on the next step to be taken. At the start of a study he will usually have background information of some kind from which he can develop an idea of the outcome of the proposal. Preferably this background information should be used to make a quantitative estimate of the outcome, that is, an estimate of the probability of each possible outcome. This estimate should then be used, in the manner outlined below, to decide what to do next. If the decision is to obtain more data, the background information and the new data should be used together to make a new estimate of the outcome, each piece or set of data being weighted in accordance with the error involved. In mathematical terms, two independent estimates, E_1 and E_2, should be combined as follows:

$$\frac{E_1 \times \sigma_2^2 + E_2 \times \sigma_1^2}{\sigma_1^2 + \sigma_2^2};$$

the standard deviation is

$$\sqrt{\frac{\sigma_1^2 \sigma_2^2}{\sigma_1^2 + \sigma_2^2}}\;.$$

If σ_2/σ_1 is small, the result reduces to E_2; that is, E_1 can be neglected. As more data are accumulated, the background information becomes less and less important, and eventually will be completely outweighed.

The authors do not wish to imply that there is any neat system for defining what items of background information are pertinent and for fitting the pertinent items together as a basis for prediction. Obviously at this stage any prediction is subject to large error. However, there is no way to avoid such predictions; one can only try to make as good an interpretation of the available data as he can, not with any expectation of eliminating all wrong decisions, but rather with the goal of

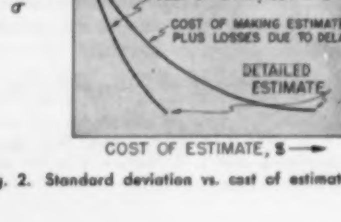

Fig. 2. Standard deviation vs. cost of estimate.

achieving a high percentage of correct decisions.

Mathematical Analysis

The mathematical procedure outlined below applies to the following situation:

1. All estimates are independent and unbiased.
2. The error distributions are normal and the standard deviations are known.
3. The objective is to maximize long-run profits in the course of a series of do-or-don't decisions.

The procedure will be given as it would be used in one specific situation with the understanding that it will also be used in other situations as they arise.

For example, we have evaluated a proposal and estimate that the incremental profit after all charges is $60,000. From our previous experience with estimates of this kind we have established that the error term on the average is equal to zero and that the standard deviation, with the scale of the proposed operation taken into account, is $100,000. We are considering whether to reevaluate the proposal using a second estimating procedure which has a standard deviation of $50,000. The cost of making the second estimate is $5,000. The cost of the first estimate was $1,000, but this has already been spent and so has no bearing on the future action.

We start by plotting our first estimate, E_1, on a profit scale ranging from minus $500,000 to plus $500,000 (Figure 3). We then draw a distribution curve centered at E_1, with a standard deviation of $100,000. This curve indicates the frequency of occurrence of actual results if we should adopt a large number of proposals, all of which were indicated by the first estimate to have an expected profit of $60,000. The area under any section of this curve represents the probability that P, the true value of the profit, will fall within the range corresponding to that section of the curve. The shaded area indicates that there is about one chance in four that accepting the new proposal will result in a loss.

If we were to make the second estimate, we should have another chance to determine whether the particular proposal we are studying actually would result in a loss or in a gain and we should have another chance to decide whether to adopt the proposal. If the second estimating procedure were completely free from error, we could make a perfect sorting of our series of proposals. Even with our imperfect procedure we should reject most of the proposals that would result in a loss and in particular should very probably reject any proposals which would result in large losses. Of course, we should also reject some proposals which would result in a small profit, but it is unlikely that we should reject any that would result in a large profit.

The probability that the second estimate will indicate the correct decision is shown in Figure 4 for two of the possible values of P. If the true value, P, is equal to −$50,000, the probability that E_2 will indicate a loss is 0.84; if P is equal to +$50,000, the probability that E_2 will indicate a profit (thus confirming E_1) likewise is 0.84; and if P is equal to zero, the probability that E_2 will indicate a profit and that E_2 will indicate a loss are both equal to 0.5. In this case, however, either decision, to accept or to reject, is correct.

In order to put a value on the gain we expect to obtain by making the second estimate, we must take into account both the probability of occurrence of each of the possible values of P, as shown in Figure 3, and the probability (for each possible value of P) that the second estimate will result in our making the correct decision. Values for the expected gain (before the cost of the second estimate is deducted) have been calculated by the mathematical approach of Grundy, Healy, and Rees (*1* and *2*). These values are plotted in Figure 5 as a function of the two parameters E_1/σ_1 and σ_2/σ_1.

For our example, the values of the parameters and of the expected gain are as follows:

$$E_1/\sigma_1 = \$60{,}000/100{,}000 = 0.6$$

$$\sigma_2/\sigma_1 = \$50{,}000/100{,}000 = 0.5$$

$$\text{Expected gain} = \underset{\text{(from Figure 5)}}{0.133} \times \underset{\sigma_1}{100{,}000} - \underset{\text{(cost of } E_2)}{5{,}000} = \$8{,}300$$

Since a net gain is indicated, we conclude that we should make the second estimate before deciding whether to adopt or reject the proposal.

However, if E_1 had been $110,000, the expected gain would be 0.050 × 100,000 − 5,000, or zero; for any value of E_1 higher than $110,000 the proposal should be adopted without making the second estimate.

Special Cases

Statistical quality control (*3*) and (*4*) of manufactured products is a special case of this general problem; one decides with respect to each lot of product whether to ship, discard, or retest, and the decision is made (usually implicitly) on the basis of the costs involved. Conversely, it might be said that the procedure outlined in this paper is the application of statistical quality control to the process of decision making.

A narrower special case concerns the number of check tests that should be made—for example, the number of pilot plant runs that should be made before commercial operation is undertaken. An engineer can make tests one at a time, deciding after each whether to continue, or perhaps time and effort can be saved if several tests are made as a group, with the cost per test thereby reduced. In either case one is dealing with a series of tests each of which has the same standard deviation. If the pilot plant tests are the only source of error and if the background information is too indefinite to have any pertinence, the standard deviation of the first estimate, σ_1, based on the test or tests already made, and the standard deviation of the second estimate, σ_2, based on the planned number of additional tests, depend only on the number of tests in each group. Values of the ratio σ_2/σ_1 are shown in Table 2 for varying numbers of tests in each group, mainly to

New Techniques for COST ESTIMATION

Table 2.—Standard Deviation vs. Number of Tests

(Standard deviation of individual tests constant)

Number of tests: First group	Number of tests: Second group	Ratio of standard deviations: Second estimate to first estimate	Ratio of standard deviations: Combined estimate to first estimate
1	1	1.00	0.71
1	4	0.50	0.45
1	16	0.25	0.24
2	2	1.00	0.71
2	8	0.50	0.45
2	32	0.25	0.24
4	4	1.00	0.71
4	16	0.50	0.45
4	64	0.25	0.24

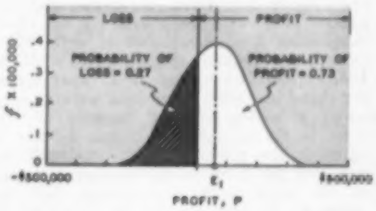

Fig. 3. Frequency distribution of profit.
Given: Estimated profit, E_1 = $60,000
Standard deviation σ_1 = $100,000

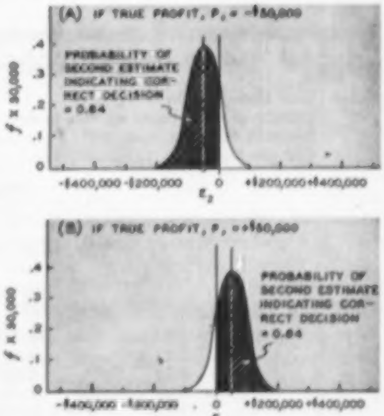

Fig. 4. Frequency distribution for result of second estimate. Given: Standard deviation of second estimate, σ_2 = $50,000.

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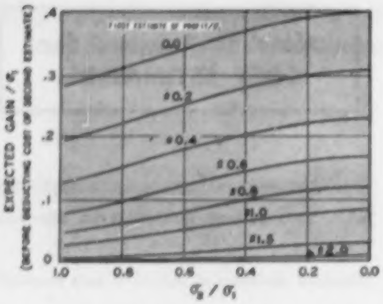

Fig. 5. Expected gain attributable to making second estimate.

emphasize the large number of additional tests needed to give any sizable reduction of error if more than two or three tests have already been made.

As an example, suppose that we have made two pilot plant tests which give us an estimated profit of $60,000, that the standard deviation of an estimate based on a single test is $100,000, and that the cost per test is $500. From Table 3 the optimum number of additional tests is five, and the expected gain if these tests are made is $2,380.

Suppose, however, that besides the error in the pilot plant tests, we have to consider the error from another source, say in our market research data. (This should probably be considered as representing the general case, with the previously described cases with a single source of error considered as simpler special cases.) It is obvious that no matter how many times we check our pilot plant runs we still may make a wrong decision because of the error in the market predictions. In such a situation the potential gains obtainable by reducing the error in the market data and in the pilot plant data should both be checked. It will usually be desirable to split the effort and to reduce the error from both sources.

Decision Theory and Common Sense

The relationships shown in Figure 5 and discussed in the examples can be stated in qualitative terms as follows:

1. **Other things being equal, the amount that should be spent on an evaluation varies with the scale of the operation being considered; in still simpler language, the engineer should concentrate his efforts on the biggest problems.**

2. **The greatest gains are obtainable from a second decision if the first evaluation indicates a relatively close decision. If the first evaluation indicates either a very large gain or a very large loss relative to the standard deviation of the first estimate, not much can be gained by making a second estimate.**

3. **The second estimate does not have to be much better than the first one in order to achieve most of the gain that might be obtained if the second estimate were entirely free from error. If several estimating procedures were available, it would be possible to select the one which would give the optimum results, that is, the one which would give the largest increase in profit after the cost of the estimate had been deducted.**

4. **If there is no better opportunity available, it may be worth while to reexamine proposals which, on the basis of preliminary estimates, are expected to result in losses, in order to salvage some of the few which might result in profits. However, it would probably be more profitable to put the additional effort into research in order to develop new and better opportunities.**

5. **If several parts of an evaluation are subject to error, it is usually preferable to improve the accuracy of each part rather than to concentrate all the effort on a single part.**

These principles, it is believed, are the ones generally used—not quantitatively but informally or semiquantitatively—in practical decision making. Thus one might say that statistical decision theory, a relatively new branch of mathematics still in the early stages of development, gives a confirmation of the decision method that has been worked out on a nonmathematical basis over a period of centuries. More important, the explicit mathematical description of the decision-making process focuses attention on the steps that ideally should be performed and on the kinds of data that are desired.

This paper has examined only the skeleton of the decision-making problem and has necessarily considered only the simplest possible kind of situation. In practice, research and evaluation are frequently inseparable and a whole series of interdependent decisions rather than a single sharply defined one may be involved. However, it may be possibie in some practical situations to follow through the entire mathematical procedure. Even in situations in which the complexity of the analysis and the difficulty of obtaining data make a completely quantitative analysis impossible, the mathematical approach should be a useful guide. Finally, this discussion suggests that research and development on methods of estimating and evaluation might be added to the earlier listing of alternatives and that effort should be allocated to this activity as a matter of routine throughout the course of successive studies involving the first four alternatives.

In summary, decision theory is never going to be a substitute for executive judgment. It is a philosophy rather than a formula for decision-making—a stimulus and reinforcement rather than a replacement for judgment. However, if more data, including data on the errors of estimating procedures, can be developed and if quantitative relationships can be worked out (hopefully for the major factors, if not for all details) the engineer should obtain a higher percentage of correct decisions—and bigger profits.

Table 3.—Optimum Number of Additional Tests

Basis:	
Tests made to date	2
Estimate of profit based on tests to date	$ 60,000
Standard deviation, one test	$100,000
Cost per test	$ 500

$$\sigma_1 = \frac{100{,}000}{\sqrt{2}} = 70{,}700$$

$$E_0/\sigma_1 = 60{,}000/70{,}700 = 0.85$$

Additional tests, n_2	σ_2/σ_1‡	Expected gain
2	1.00	(0.038 * × 70,700) — (2 × 500) = 1,690
3	0.82	(0.052 × 70,700) — (3 × 500) = 2,180
4	0.71	(0.061 × 70,700) — (4 × 500) = 2,310
5	0.63	(0.069 × 70,700) — (5 × 500) = 2,380 †
6	0.58	(0.073 × 70,700) — (6 × 500) = 2,060

* From Figure 5.
† Optimum.
‡ $\sigma_2/\sigma_1 = (\sqrt{2/n_2})$

Acknowledgment

We acknowledge the major contributions made by S. T. Hadden and F. W. Winn during the early phases of this study, and we express our appreciation to our supervisors in Socony Mobil Oil Company, Inc., for their forbearance when we should have been concentrating on more immediate problems.

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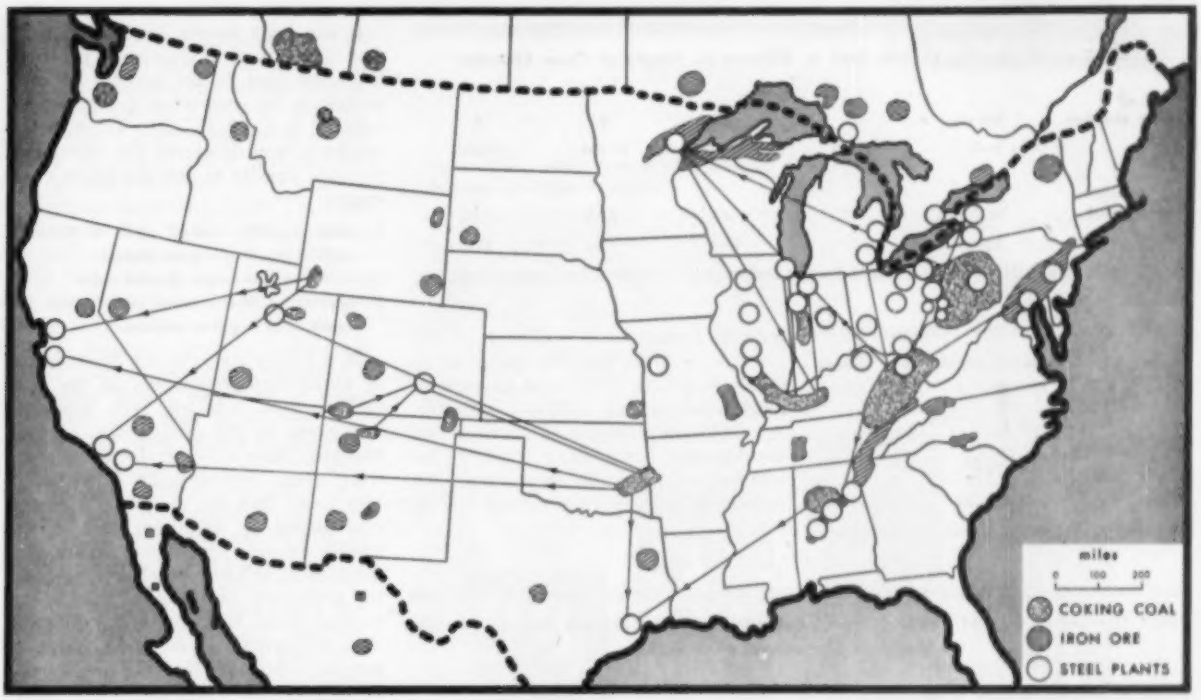

Location of iron and steel plants, iron ores and coking coal in U.S.A. (1951), showing movement of coking coal to major iron and steel plants.

In the United States, as in Europe, the location of iron and steel industries has been away from the sites of good coking coal, or coal capable of being readily transformed into metallurgical grade coke. In this article, author Patel reviews these trends, and describes new coking facilities of unusual flexibility recently constructed in India. The operation of such facilities as these should advance the amount of information available as to the use of increased oven height and stamping as important variables, as discussed herein.

COAL CARBONIZATION

Improvement in coke quality by stamping and increased oven height

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The iron and steel industry, until about the first one or two decades of this century, was more or less confined to areas with deposits of coal having good coking qualities. The most important iron and steel works in the U. S. were, therefore, located around Pittsburgh. In Europe also, most of the important iron and steel works were situated in areas of coal deposits. With the industrial development of areas further removed from centers of good coking coal production, and with the introduction of the use of iron scrap in steel making, the location of new iron and steel plants has, in recent years, shifted to areas having other favorable economic factors, such as availability of iron ores as well as iron scrap both at reasonable cost and the proximity of markets for steel products. In recent decades, therefore, iron and steel plants have been established in the western states of the U. S. and in Upper Silesia, Czechoslovakia, the Saar, Lorraine, Austria, Italy, and other areas of Europe far from deposits of good coking coals.

When the European iron and steel plants were initially located in the new areas, it was necessary in many cases to transport good coking coal to these locations. Later either the transportation cost of good coking coals made the production of iron and steel in those areas comparatively uneconomical, or

Table 1.—Bulk Density of Dry Coal in Relation to Height of Oven Chamber

Height of oven chamber	meters:	3	4	5	6
	feet:	9.842	13.123	16.404	19.685
Bulk density of dry coal	lb./cu.ft.	45	46	47.2	50
	kg./cu.m.	721	736	756	800

Table 1A.—Screen Analysis for Charge in Table 1

mm.	in.	%
3–7	1/8–9/32	28
2–3	5/64–1/8	15
below 2	below 5/64	57

political factors made it difficult or impossible. Means had, therefore, to be found to use as large a percentage of local, poorly coking coals as practicable. A considerable amount of research and development work was carried out which made it feasible to produce good metallurgical coke from poorly coking coals.

Table 1B.—Comparison of Performance of Coke Ovens with Different Chamber Height for the Same Throughput of Coal *(14)*

Height of oven chamber up to top	9 ft. 10 in.	13 ft. 1½ in.	16 ft. 4¾ in.	19 ft. 8¼ in.
Effective volume of oven chamber ....cu.ft.	537	736	935	1,132
Bulk density of coal in oven chamber ...lb./cu.ft.	46.2	46.8	47.4	48.1
Weight of charged coal (dry)/oven chamber ....short tons	12.38	17.20	22.10	27.20
Capacity/oven chamber ....short tons/24 hr.	14.8	20.7	26.5	32.6
Required number of ovens	224	160	125	102
Number of ovens to be pushed in 24 hr.	269	192	150	122
Operational staff for the ovens ....men	84	63	51	45
Coke output/man and shift...........short tons	30.8	41.0	50.6	57.40

It has been known for a long time that bulk density of the charge plays an important part in the process of carbonization for improving the quality of coke *(4, 5, 6, 10, 11, 13)*. Three methods have been developed for increasing the bulk density of the charge in coke ovens:

1. using properly crushed coals of different particle sizes in the same charge
2. increasing the height of coke ovens
3. compressing the crushed coal charge by means of a stamping machine.

In the early stages of the development of by-product coke ovens in the coal carbonization industry, little attention was given to the particle size of coal charged, since only good coking coals were used. Subsequently, however, it was found that the particle size of the coal played an important part in the quality of coke produced. When the question of utilizing poorly coking coals for producing metallurgical coke arose, it was found that, by using different sizes of particles in the same charge in proper proportion, the bulk density can be increased in many cases, thus yielding coke of desirable quality *(4, 11, 13)*.

Increase in the height of coke ovens also can contribute in some cases to an increase in bulk density *(6, 11)*. Some poorly coking coals, which did not yield a good coke, gave desirable results when carbonized in coke oven chambers of greater height. Coke oven batteries with chambers 6 m. or 19 ft., 8 in. high,

Table 2.—Slot-type Coke Ovens Completed and Abandoned in the United States in 1952

		Ovens						
		In existence Dec. 31		New			Under construction Dec. 31	
State	Plants in existence Dec. 31	Number	Annual coke capacity (net tons)	Number	Annual coke capacity (net tons)	Abandoned during year [1]	Number	Annual coke capacity (net tons)
Alabama	7	1,383	6,596,800	125	645,300	82	25	94,000
California	1	135	566,000	...	....	...	90	466,500
Colorado	1	266	1,000,000	...	....	...	...	....
Connecticut	1	70	425,000	...	....	...	...	....
Illinois	8	910	3,941,400	15	73,000	5	27	155,000
Indiana	5	1,960	9,709,700	75	480,000	70.	70	346,100
Kentucky	1	120	720,900	...	....	...	76	515,000
Maryland	1	496	2,770,400	65	412,000	120	126	824,000
Massachusetts	1	204	1,260,000	...	....	...	...	....
Michigan	4	621	3,298,800	37	195,700	...	70	480,000
Minnesota	3	212	881,700	29	121,000	57	29	121,000
Missouri	1	96	365,000	40	153,300	...	...	....
New Jersey	2	341	1,500,000	...	....	...	...	....
New York	5	973	5,459,400	76	492,000	218	...	....
Ohio	15	2,411	11,825,700	171	963,700	45	133	700,500
Pennsylvania	14	3,900	18,888,800	251	1,357,400	61	429	2,281,500
Rhode Island	1	65	250,000	...	....	...	...	....
Tennessee	1	44	250,000	...	....	...	...	....
Texas	2	125	688,500	...	....	...	...	....
Utah	2	308	1,212,300	...	....	...	...	....
West Virginia	5	768	4,297,600	63	424,000	...	...	....
Wisconsin	1	200	520,000	...	....	...	...	....
Total 1952	82	15,608	76,428,000	947	5,317,400	658	1,075	5,983,600
Total 1951	83	15,319	74,228,400	696	3,869,100	359	1,446	8,134,500

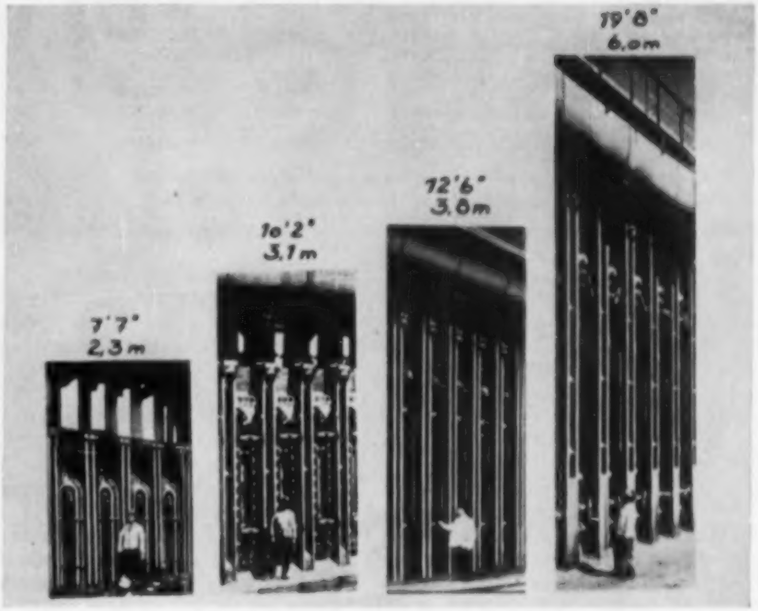
[1] Includes ovens dismantled for rebuilding.
Reprinted from U. S. Bureau of Mines, "Minerals Yearbook" (1952) *(15)*.

have been built and successfully operated. Figure 1 shows photographs of coke oven chambers of different heights from 2.3 to 6 m., or 7 ft., 7 in. to 19 ft., 8 in. Table 1 gives bulk density of dry coal in relation to the height of coke oven chambers, with the screen analysis of the charge as shown in Table 1A. Bulk density will vary in the same chamber with particle sizes used in the charge.

The bulk density can be varied, to some extent, by the use of different particle sizes in coke oven chambers of different heights. Optimum conditions can be obtained by proper adjustment of different factors by which, in some cases, good coke may be derived from poorly coking coals. There is, however, a limit to the increase in the bulk density obtained through adjusting the height of coke oven chamber and particle size of coal. At present, it is possible to attain a bulk density of about 880 kg./cu.m. or about 55 lb./cu. ft. in 6-m. high oven chambers with wet coal containing about 10% moisture (*11*). Beyond this limit, the bulk density can be increased only by compressing the charge by means of stamping.

The use of 6-m. high coke ovens not only brings about an increase in the bulk density of the charge thereby improving the quality of coke, but also brings about an appreciable economy in the production of coke on account of the higher output per oven. This can be seen from Table 1-B.

Fig. 1. Comparative views of coke oven chambers of different heights.



The Stamping Process

By the stamping process it is usually possible to reach a bulk density of about 1,000 kg./cu.m. or about 63 lb./cu.ft. with wet coal, irrespective of the height of the oven chamber. In some exceptional cases, however, bulk density as high as 1,100 kg./cu.m. or about 69 lb./cu.ft. has been attained with wet coal (*6*).

It should, however, be noted that, when the process of coal carbonization in by-product coke ovens was developed, the charge was stamped in the initial stages of this development, even when good coking coals were used. Subsequently, stamping the charge was found unnecessary in most cases. From about 1895 onwards, for a number of years, the practice of stamping the charge was more or less abandoned at most of the coke oven batteries. But subsequently a revival has taken place with the increased use of poorly coking coals in the coal carbonization industry in European countries.

Advantages of the stamping process were described in technical literature as early as 1884. Its use for improving the quality of coke and for producing hard coke from poorly coking coals has been specifically mentioned (*1, 2*). Re-

Fig. 2a. Portable chimney.

Fig. 2b. Portable combustion car.

Table 3.—Age of Slot-type Coke Ovens in United States
(Dec. 31, 1952 [1])

Age	Number of ovens	Per cent of total	Total Annual coke capacity (net tons)	Per cent of total
Under 5 years	2,660	17.0	14,584,000	19.1
From 5 to 10 years	1,989	12.8	10,530,000	13.8
From 10 to 15 years	2,470	15.8	13,632,600	17.8
From 15 to 20 years	1,018	6.5	5,368,600	7.0
From 20 to 25 years	667	4.3	3,728,000	4.9
25 years and over	6,804	43.6	28,584,800	37.4
Total	15,608	100.0	76,428,000	100.0

[1] Age dates from first entry into operation or from last date of rebuilding.
Reprinted from U. S. Bureau of Mines "Minerals Yearbook" (1952) (*15*).

Table 4.—Coke Ovens Using Stamping Process in Different Countries and Their Daily Throughput

Country	Number of ovens	Throughput of wet coal in metric tons/ 24 hr.
1. Czechoslovakia	336	6,730
2. England	260	2,425
3. France	538	8,470
4. India (Sindri)	60	1,050
5. Yugoslavia	75	1,400
6. Saar-District	732	9,385
7. Saxony	72	900
8. Upper Silesia	416	6,415
Total:	2,489	36,775

cent literature on coal carbonization deals in detail with the operation of the stamping machines and their special application in improving the quality of coke, as well as in increasing the use of poorly coking coals as such, or mixed in appreciable proportion with good coking coals (*4, 5, 9, 13*).

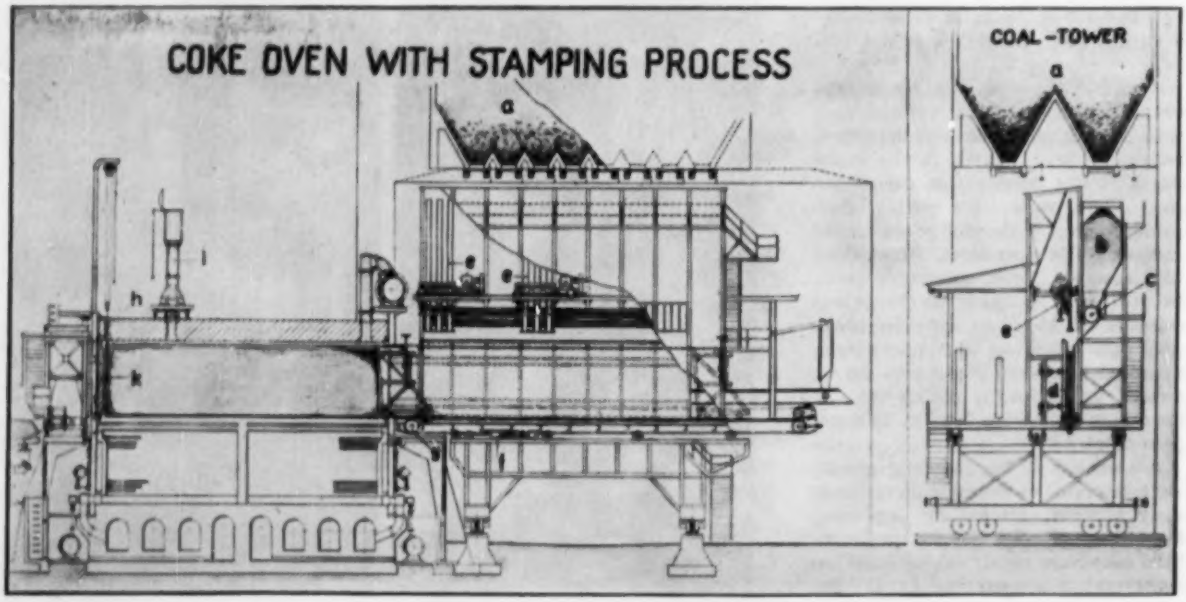
The by-product coke oven industry in the U. S. was introduced and developed, in place of beehive coke ovens, to an appreciable extent only during the first two decades of this century. It has not, therefore, been found necessary to stamp the charge in U. S. coke ovens, as good coking coals have been consistently used in the country so far. The stamping process, therefore, has not come to be known at all in the U. S., and one does not find any real mention of stamping batteries even in American technical literature on coal carbonization, in spite of the fact that there is a vast literature on that subject in Europe in general and in Germany in particular. Table 2 lists slot-type coke ovens in 1952 in the U. S. and Table 3 gives the age of the slot-type coke ovens at the end of 1952.

At one time stamping of the coal charge was an unpleasant, tedious, and laborious operation. But several improvements, patented and otherwise, have been introduced in the operation of the stamping machine during the last twenty years, which have made the stamping of the coal charge an operation as smooth and almost as easy as the conventional top filling process. Due to the increased use of electrically worked devices, all the unpleasantness of the operation has been eliminated. One of the disagreeable features of the stamping battery was the dense smoke that issued from the top of the coke oven while the stamped charge was inserted into the chamber. This has been remedied now by burning the gases with compressed air which gives a practically smokeless flame from the chimney of the portable combustion car on the top of the ovens, drawing gases from the chamber. Figure 2 shows the smoke and gases, as well as the smokeless flame, coming out of the chimney before and after this improvement was introduced.

STAMPING MACHINE

With the improvement in the stamping machine and with the development of the iron and steel industry in those European areas which have only poorly coking coals, use of the stamping proc-

Fig. 3. Diagram of stamping machine: a—coal tower; b—charging bunker; c—feeding roller; d—stamping box; e—stamping apparatus; f—drive; g—chain and chain wheel; h—shield pivot; i—filling gas combustion car; and k—shield.



ess has increased appreciably in recent years. Table 4 lists the number of ovens operating with stamping process and their daily throughput of wet coal in metric tons in different countries. From Table 4 it will be seen that at present (August, 1955) 2,489 coke ovens are operating in different parts of the world by the use of the stamping process with a throughput of 36,775 metric tons of moist coal in 24 hr. This means that about 8 million metric tons of coke/year are produced in different countries by the stamping process. Some coke oven bateries with stamping process are under construction and some are in active planning stage at present.

A diagram of the stamping machine of modern design is shown in Figure 3.

It comprises all units of equipment and devices for stamping the coal charge, inserting the coal cake into the oven chamber, extracting and setting-in the oven doors, and pushing out the coke. The weight of the machine varies from 300 to 450 tons depending upon the capacity of the oven chamber, exclusive of the weight of the coal to be charged. Bunker (a) of the coal tower is arranged over the tracks of the stamping machine. Stamping machine coal bunker (b) has a capacity sufficient for charging three ovens. Roller (c) with grooves under the machine bunker, feeds coal to the stamping case (d) in the desired quantity by adjusting the revolution of the roller.

A modern stamping machine has two sets of three stamps each, which are lifted by means of driving belts or magnetic rollers, and fall on the coal by their own weight. The mechanism is so controlled that the stamps are lifted to the same height of about 2 ft. from the top of the coal layer in case (d) automatically; *i.e.*, the distance of up-and-down movement of the stamp is practically the same throughout the operation. One wall of the stamping case (d) is adjustable. The two sets of stamps are mounted on two electrically operated trolleys (e). Both trolleys move in horizontal direction back and forth over the entire length of the stamping case, and their movement is reversed automatically when they touch each other.

The movements of the trolleys and the stamps are simultaneous, *i.e.*, the trolleys move in horizontal direction, the stamps in vertical direction, and all their movements are automatically controlled. The driving gear (f) moves the cake-containing case to the oven chamber by means of the chain wheel (g) which permits the smooth insertion of the stamped cake of coal into the oven chamber with the help of the chain. Pivot or hook (h) enables the lifting of shield (k) which keeps the cake firm during insertion into the chamber. The shield is extracted at the end of the operation through the top of the chamber and returned to the machine.

In the stamping process one machine performs all operations from charging the coal into the oven chamber to pushing out the coke. In the conventional filling process the charging of coal is done by larry car operating on the top of the ovens and the pushing out of the coke is done by the pusher machine, which also levels the charged coal and

Fig. 4. Photograph of stamping machine.

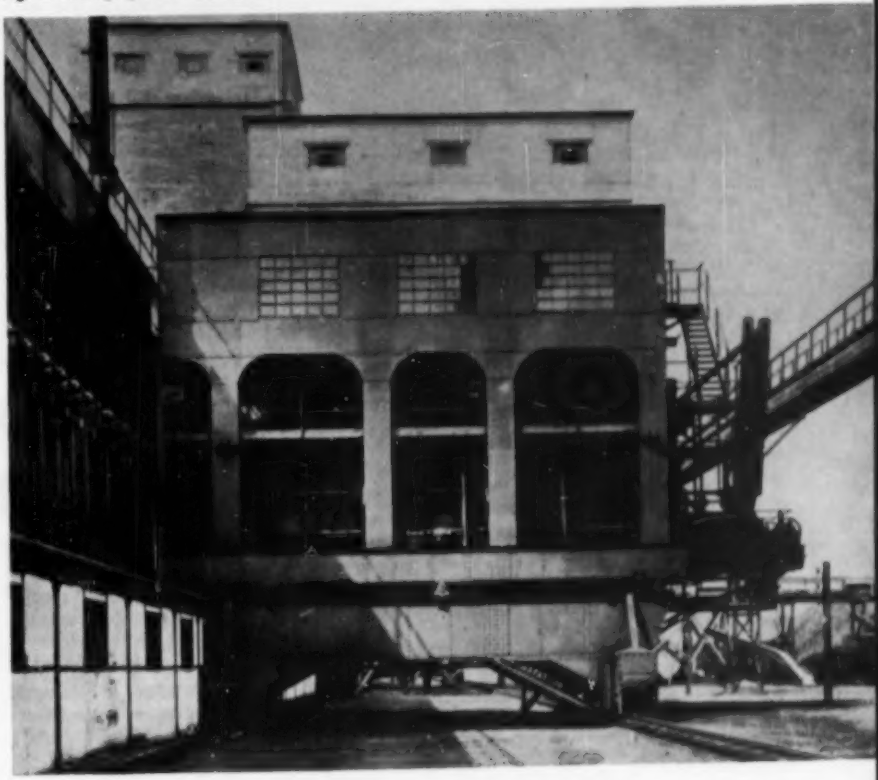


Table 5.—Analysis of Coals Used in Coke Making by Stamping Process

Mine	Location	Raw coal ash %	Raw coal water %	Volatile matter on moisture and ash-free basis %
1. Upper Silesia				
Delbrück	Hindenburg	3.6–10.6	2.3–5.8	36.5
Donnersmarck	Schwientochlowitz	4.5	6	42
Hedwigs-Wunsch	Hindenburg	16	3	36.5
Hohenzollern	Beuthen	6.3–7.3	6.5–6.7	33.9–35.2
Königin-Luise Ostfeld	Hindenburg	3.4–11.0	1.4–7.2	32.0–37.1
2. Czechoslovakia				
Barbara		3.5	8.7	33.9
Fortschritt		4.2	7.5	40.3
Hohenegger		3.3	10.4	33.6
Johanna-Maria		3.0	11.4	37.9
3. Saar-Area				
Clarenthal	Geislautern	4.0–7.7	2.4–7.3	39.2–40.9
Heinitz	Heinitz	6.1–7.7	1.2–3.2	33.1–33.5
Reden	Neunkirchen	4.5–7.0	2.3–9.2	33.5–36.1
Luisenthal	Püttlingen/Saar	8.5–9.3	7.6–11.9	36.9–38.6
Velsen	Geislautern	5.5	3.5	41.5
4. Saxony				
Deutschland	Oelsnitz i.S.	3.4–4.6	3.5–4.1	35.1–37.5
Morgenstern	Zwickau	5.1–7.0	6.7–8.8	34.8–39.8
5. India				
Sindri	Sindri	13.9–15.6	2.3–4.4	41.8–45.1

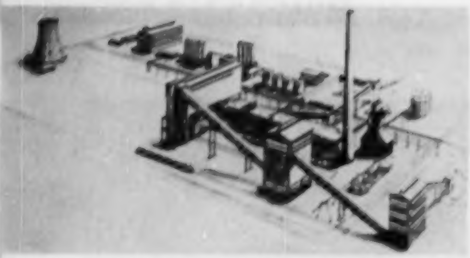


Fig. 5. Artist's sketch of Sindri coke oven battery.

extracts and replaces the doors on the machine side. Figure 4 is a photograph of a modern stamping machine.

COALS FOR STAMPING

Table 5 shows the analysis of some of the poorly coking coals used in coke making by means of the stamping process. From the table it will be seen that generally coals with appreciably high volatile matter content are used for carbonization by stamping process.

The importance of plasticity of coals during the process of carbonization has now been found an important factor in determining experimentally the suitability of coals for producing good coke. Plasticity curves drawn from the results obtained in dilatometer tests assist considerably in many cases to ascertain the extent of suitability of different coals for coke making (*3, 8, 12*). This development is likely to make it possible to determine in many cases whether a coal or a mixture of coals is likely to yield good coke in low or high oven chambers or by stamping process (*3, 8, 12, 13*).

Mixing finely ground coke breeze (coke particles of diameter usually less than 1/8 in.) with pulverized coal for charging into the coke ovens has resulted in many cases in an improvement in the quality of coke produced from some poorly coking coals (*7, 13*). There are some coke oven batteries in European countries where recycling of coke breeze into the coal charge has become a regular practice. In some cases this has not only improved the quality of the coke but has also resulted in more economic utilization of coke breeze.

The New Sindri Plant

In India the reserves of good coking coals are small for the iron and steel industry, which is expanding at a considerable rate. In view of this, while planning the battery for producing coke for the Sindri fertilizer plant, it was thought desirable to use in this battery poorly coking coal containing high volatile matter instead of good coking coal. Two objectives were before the planners of the battery: one was to use poorly coking coal to show a way toward conservation of good coking coals, and the other was to get an appreciably large quantity of coke oven gas for use as a source of hydrogen for the additional production of ammonia at the Sindri fertilizer plant in connection with its expansion program. These two objectives suggested the installation of a stamping battery. In order, at the same time, to improve the quality of the coke, as well as to find some more economic use for coke breeze, it was decided to have facilities for recycling the breeze in the coal charged to the battery. This and other considerations resulted in the decision to set up a coke oven battery at Sindri which has facilities for (1) conventional filling process, (2) stamping process, and (3) recycling of finely ground breeze into the charge.

This battery has been constructed and has been operating satisfactorily since November, 1954. It is the only commercial scale coke oven battery so far constructed which has all three facilities combined in one unit. Commercial scale experiments can be carried out in this battery, based on practical results obtained in laboratory or pilot plant, as it has a capacity of 1,060 metric tons of wet coal/day. The battery has been designed and constructed by Messrs. Carl Still of Recklinghausen, West Germany, as a turnkey project. Figure 5 shows a perspective drawing of the Sindri coke oven battery which, over and above the efficient and economic supply of coke and gas to the Sindri fertilizer plant, is likely to play an important part in solving problems connected with the production of good coke from poorly coking coals, as contemplated by the planners who provided these different facilities.

More Developments in Sight

Reserves of good coking coals are limited in many countries of the world, and even in the U. S. the question of the inadequacy or rapid dwindling of the reserves of good coking coals is now being discussed. Some recent developments indicate the possibility of replacement of coke ovens by other processes for making coke, or elimination of the use of metallurgical coke as such from iron and steel making processes. These developments will take some time before they are perfected and their economics are established. The coke oven chambers of greater height and the stamping process have played and are playing an important part in the coal carbonization industry and consequently of the iron and steel industry of some of the European countries or areas which do not have good coking coal deposits. In finding ways and means for conservation of good coking coals, the place of 5- and 6-m. high oven chambers, and that of the stamping process in the coal carbonization industry deserve more consideration and attention in the U. S. than has thus far been given them.

Acknowledgment

The author wishes to acknowledge the valuable assistance given by the members of the Technical Division of Messrs. Carl Still in preparing the drawings and photographs, and in putting at his disposal unpublished data and facilities for searching old literature.

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Fig. 1. Pilot plant model of pump-mix mixer settler.

The design principles of the pump-mix mixer settler are described briefly and some of its operating characteristics are presented. Twelve runs were made with a methyl isobutyl ketone–acetic acid–water system to show the relationship of stirrer speed and total flow to efficiency. With the proper selection of the variables, 95 to 100% efficiency was obtained. Also, some comments based upon several years of pilot plant operation are presented.

Some operating characteristics of the PUMP-MIX MIXER SETTLER

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During the past several years there has been great interest in solvent-extraction processes in the atomic energy field, and as a result several new types of contactors have been developed. One of these is the pump-mix mixer settler, which was developed at the Knolls Atomic Power Laboratory. Although this contactor was developed for use in the atomic energy field, it became apparent from the performance of the unit that it offered advantages for use in other solvent-extraction processes. In order to make the unit available for general use, the design principles were declassified and published (*1*). This paper presents additional data on the performance of the unit as well as a brief summary of the design principles.

Equipment Construction

The unit used in this investigation is a pilot plant model consisting of sixteen stainless steel stages arranged side by side (Figure 1). Each stage is a rectangular box 3 in. wide by 5 in. high by 11 in. long divided into two sections, a mixing section and a settling section. The mixing section consists of two chambers connected by a 1⅞-in.-diam. circular hole in a horizontal plate. The top chamber is 3 in. wide by 3 in. long by 2½ in. high and the bottom chamber is 3 in. wide by 3 in. long by 1¾ in. high. The lower portion of the bottom chamber is blanked off to cut down on bank holdup. The rest of the stage is the settling section (Figure 2). The volume of each settling section is 1.9 liters and the total volume per stage is 2.62 liters. Every mixing section contains a stirrer on a shaft which enters the mixing section through the top of the stage.

The shaft supporting the stirrers is mounted in ball bearings and the stirrers are driven by a belt-and-pulley arrangement (Figure 3). Speed control is obtained by means of a G.E. thymotrol rectifier controlling a ¼-hp. D.C. shunt-wound motor. The stirrers themselves are centrifugal pump types with mixing blades on the upper edge, as shown in Figure 3, and an intake tube which extends through the hole in the horizontal plate into the lower part of the mixing section (Figure 2). The upper part of the mixing section is connected to the settling section by a series of L-shaped baffles which keep the settling section calm but do not add appreciable pressure drop to the system. The ports between stages are slots 2⅛ in. wide by ⅜ in. high. It is important that these ports be as large as possible to cut down on pressure drop between the stages. The light-phase port is baffled to prevent back mixing and has a boxlike arrangement to draw light phase from the top of the preceding settling section. The heavy-phase port is not baffled but is of a boxlike construction and draws heavy phase from the bottom of the preceding settling section; the heavy phase enters the mixing section at the tip of the impeller. This boxlike arrangement is known as the heavy-phase "chimney." Both the light- and heavy-phase weirs are fixed, but flow over the aqueous weir is controlled by means of a jack leg and nitrogen pressure on the weir. Pressure on the weir is maintained constant by means of a mercury manostat.

The entire unit is mounted on a wooden table 4 ft. high, 3 ft. wide, and 5 ft. long. End streams are collected in 55-gal. drums stored beneath the table top. The feed tanks are 55-gal. drums fitted with centrifugal pumps which send the feed through rotameters to the bank.

Design Principles

The pump-mix mixer settler was developed to provide the following advantages:

1. High efficiency over a wide range of operating conditions.
2. Reliability of operation.
3. Simplicity of control.
4. Flexibility to allow for process variables.
5. Ease of maintenance.
6. A minimum investment for both associated equipment and building.

Mixer-settler equipment most closely approximates laboratory techniques for carrying out liquid-liquid extractions and is inherently as predictable in operation.

The design features of the pump-mix mixer settler have been described in detail by Coplan, Davidson, and Zebroski (*1*), and so a detailed dissertation will not be presented here. As the name implies, in mixer-settler equipment the two phases are alternately mixed and allowed to separate in such a manner that the flow is stage cocurrent and over-all countercurrent (Figure 4).

The heart of the pump-mix mixer settler is the pump-mix impeller, which controls the interface in the preceding stage. When the level of the heavy phase drops below the intake tip of the impeller, the light phase and suspended heavy phase are recirculated through the hole in the horizontal plate until the heavy phase builds up to the impeller tip once again (Figure 5). This action results in the light phase being what is commonly known as the "continuous" phase, as the heavy phase is always suspended in the light phase when the unit is operating properly. It is, therefore, necessary that the pump-mix impeller have a pumping capacity greater than the aqueous flow rate; otherwise the bank would become flooded with heavy phase and there would be no interface control.

The heavy phase "chimney" between the settling and mixing sections eliminates the

effect on the interface level of a density difference between stages, since the heavy phase in the chimney has the same density as the heavy phase in the settling section. This is particularly important in complex flow sheets where large density differences may exist between extraction and refluxing sections.

The important hydraulic considerations of the pump-mix unit may be listed as follows:

1. The heavy phase is transferred from stage to stage by the pumping action of the impeller.
2. The interface in the mixing section is maintained at the tip of the stirrer intake port by the pump-mix impeller.
3. The light phase flows through the bank under a pressure gradient created by appropriate differences in levels in the standpipes.

It is important to note that the flows through the bank are sensitive to pressure drop and that ports between stages must be designed for very low pressure drop through the ports.

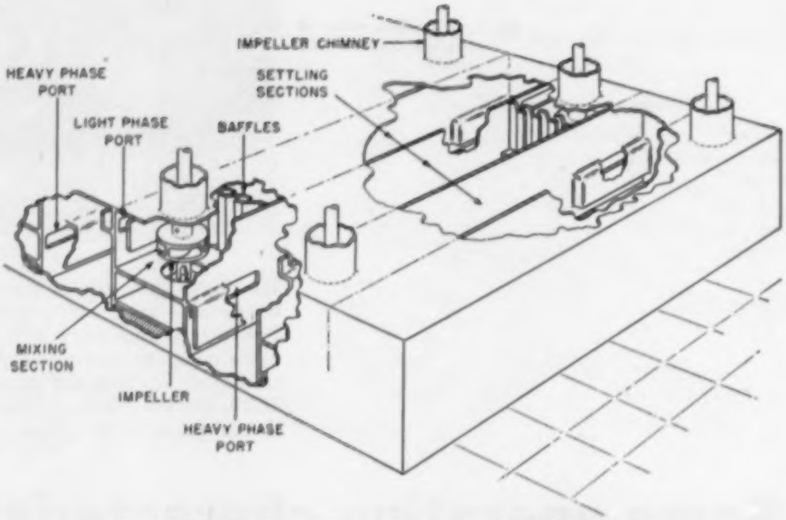


Fig. 2. Drawing of pump-mix mixer settler showing adjacent stages.

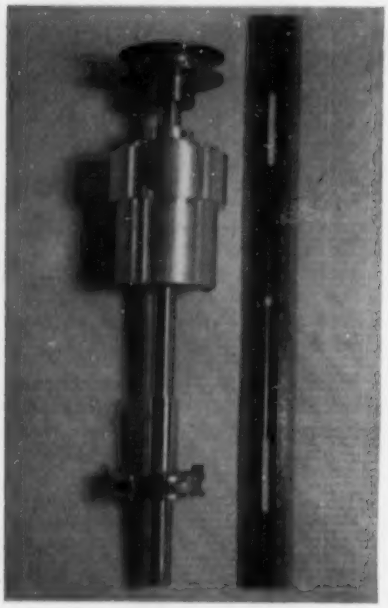


Fig. 3. Supporting shaft for stirrers.

Procedure

CHOICE OF SYSTEM

The methyl isobutyl ketone (hexone)–acetic acid–water system* was chosen because it has two characteristics which are desirable for determining efficiency by the McCabe-Thiele type of diagram: a straight equilibrium line and a slight and constant mutual solubility of organic and aqueous phase. In addition the components are inexpensive and available and the analysis of samples is simple and accurate.

CHOICE OF FLOW SHEET

The flow sheet was chosen so that there would be about a five-fold reduction in concentration between the organic feed and raffinate in eight stages. In this way the concentration change between stages was large enough to be determined accurately.

RUN PROCEDURE

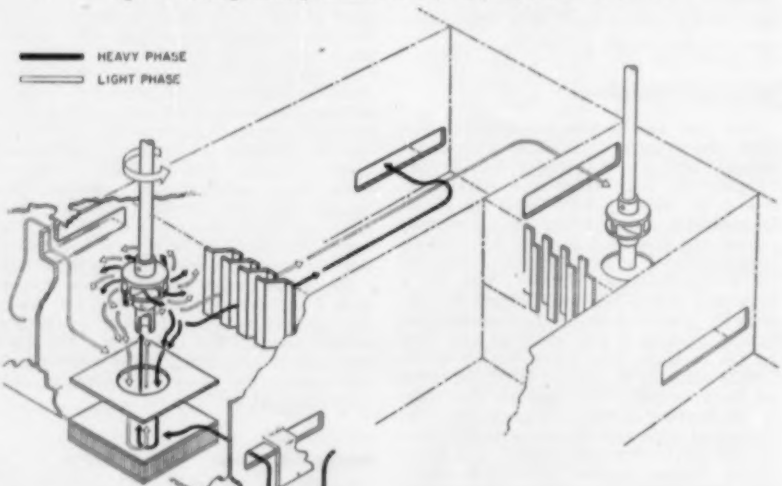
The runs were made in series of three at a constant stirrer speed, one at each set of flow rates. Four series were made, or a total of twelve runs. Before each run the organic feed was saturated with aqueous and the aqueous with organic to minimize any volume change between phases. The rotameters were calibrated for each run and readings of the feed tanks were taken at intervals as a check on the flow rates.

Every run was continued until three throughputs had been made. End-stream samples were then collected, and interstage samples were taken of both phases in each stage. Selected interstage samples of both phases were divided into two portions. One portion was analyzed directly and the other equilibrated and then analyzed. By this procedure the equilibrium line was determined for each series of runs.

ANALYTICAL METHOD

The aqueous samples were analyzed by titrating with a standard sodium hydroxide solution to a phenolphthalein endpoint. The organic samples were analyzed by extracting the acetic acid with a standard sodium hydroxide solution and then back titrating with nitric acid to a phenolphthalein endpoint. The accuracy of these methods is estimated to be ±1% for concentrations greater than 0.05 molar and ±5% for lower concentrations.

Fig. 4. Drawing showing direction of flow in pump-mix mixer settler.



* Data are on file as document 4846 with the American Documentation Institute, Photoduplication Service, Library of Congress, Washington 25, D. C., and may be obtained for $2.50 for photoprints or $1.75 for 35-mm. microfilm.

Results

The figures for efficiency reported in this paper are the ratio of the theoretical stages to the actual stages used multiplied by one hundred. The theoretical stages were determined from a McCabe-Thiele diagram.

As stage samples were taken, the operating line could be accurately determined. The equilibrium line was determined by equilibrating stage samples in the laboratory and analyzing each phase. It was thereby determined that the equilibrium line is not straight at very low acetic acid concentrations but has a slight dip, which is due to the ionization of acetic acid in the aqueous phase and is appreciable only at low concentrations. For a straight equilibrium line this ionization should be repressed by acetate ion, for instance, in the form of sodium acetate. A formula which illustrates this can be developed as follows:

$$E_{HAc} = K = \frac{[HAc]_{org}}{[HAc]_{aq}}$$

$$k = \frac{[H^+]_{aq}[Ac^-]_{aq}}{[HAc]_{aq}} = 1.85 \times 10^{-5}$$

(for dilute solutions)

$$Eg = \frac{[HAc]_{org}}{[HAc]_{aq} + [H^+]_{aq}}$$

$$= \frac{E_{HAc}}{1 + \dfrac{[H^+]_{aq}}{[HAc]_{aq}}}$$

$$Eg = \frac{E_{HAc}}{1 + \dfrac{k}{[Ac^-]_{aq}}}$$

$$Eg = \frac{K}{1 + \dfrac{k}{[Ac^-]_{aq}}} \qquad (1)$$

Therefore, any small amount of added acetate ion will make the denominator essentially equal to 1 and the gross distribution coefficient will be constant (at low acid concentrations). If no acetate ion is added, then the acetate ion present from ionization of very dilute acetic acid will be small and the gross distribution coefficient will be decreased.

The variables investigated in this report were stirrer speed, throughput, and efficiency. No attempt was made to alter the physical dimensions to get an optimum mixer-settler design for this system. As it was necessary to use only eight stages of the sixteen-stage bank to meet flow-sheet requirements, the ports between the eighth and ninth stages were blocked off with specially constructed port covers. An organic weir was inserted in the window of the eighth stage to provide an outlet for the organic phase.

In the determination of the efficiency of solvent-extraction equipment it is important to choose the proper flow-sheet conditions, as may be noted from the system hexone–acetic acid–water used in this experiment. The equilibrium line has a slope of approximately 0.5 (Figure 6) so the operating line should have a slope near 0.5 for a good appraisal of the equipment. If the slope varies too much from this value, a "pinch" will occur between the operating and equilibrium lines, making it difficult to determine the theoretical number of stages required for the extraction. When a pinch occurs, small errors in analysis will result in large errors in the determination of the number of theoretical stages required. This effect makes it impractical to show with a given system the effect on efficiency of widely varying flow ratios.

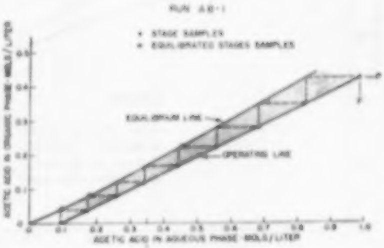


Fig. 6.

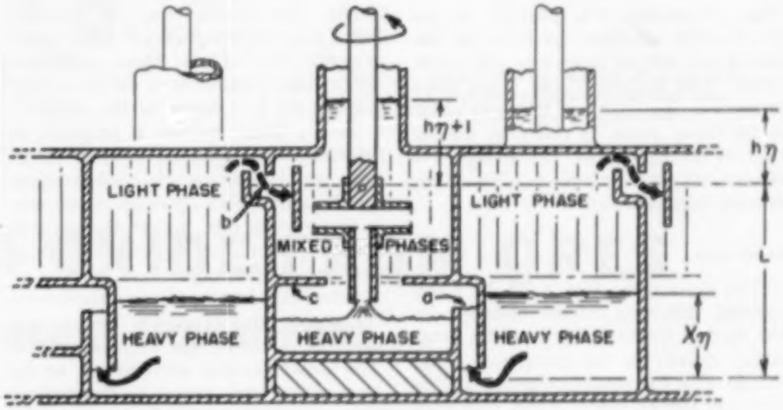


Fig. 5. Elevation of pump-mix mixer settler, showing three adjacent stages.

Data

Twelve runs were made to determine the operating characteristics of the unit. Typical McCabe-Thiele–type plots of the data are shown in Figures 6 and 7. The individual stage efficiencies are high. The data taken from these runs can be summarized in Figure 8, which is plot of efficiency vs. throughput at various stirrer speeds. These data indicate that 95 to 100% over-all efficiency can be obtained by proper selection of stirrer speed and throughput. If higher throughputs are desired, then higher stirrer speeds must be used. It should be pointed out that the impeller design is important and that placing more mixing-blade area on the impeller yields higher efficiency at all stirrer speeds. The data also show that the unit is not so efficient when extracting the acetic acid from the or-

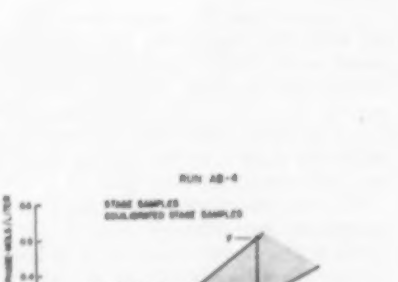


Fig. 7.

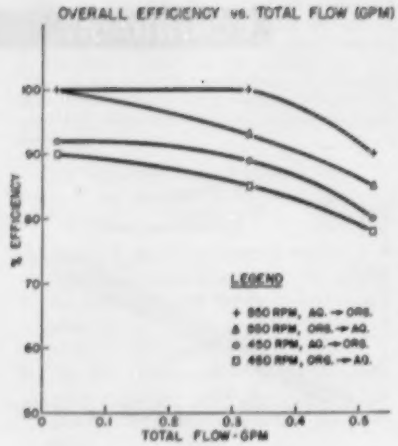


Fig. 8.

ganic to the aqueous phase as from the aqueous to the organic. This is due probably to the fact that the organic phase is always continuous and extraction is into the droplets of aqueous phase; however, it is possible to get 95 to 100% efficiency by lowering the throughput and/or increasing the stirrer speed. The inventors have given some thought to dispersing of the light phase in the heavy phase by changing the design of the equipment, but to date this change has not been necessary to satisfy process requirements.

Conclusion

The data show that a 95 to 100% over-all efficiency can be obtained for the methyl isobutyl ketone–acetic acid–water system in the pump-mix mixer settler with the proper selection of flow rate and stirrer speed. From interstage samples taken it was also shown that high individual stage efficiencies were obtained.

It appears from the results that transfer from the organic to the aqueous phase in this unit is more difficult than transfer from aqueous to organic. This may be due to the fact that the organic is a continuous phase and the transfer must take place into the aqueous droplets rather than out from them.

Over the range of stirrer speeds investigated, the efficiency was proportional to the stirrer speed. Only at the highest stirrer speed, of 550 rev./min., was the over-all efficiency 95 to 100%; this speed, therefore, represents the minimum mixing intensity required for this system.

Comments

One of the most impressive features of the pump-mix mixer settler is the simplicity of operation. Many of these units have been run at Knolls Atomic Power Laboratory over a period of several years with a minimum of operating trouble. The unit is hydraulically stable, and so minor changes in flow rates or feed concentrations do not upset the operation. All stirrers can be operated at the same speed and the units can be shut down and restarted after several days with no draining or refilling; in other words, an interrupted operation can be continued as if no interruption had occurred.

In addition, the unit can easily be adapted to flow sheets requiring center feeds or reflux section. Many such complex flow sheets with a wide variety of flow ratios have been investigated. Other advantages of the unit are the positive control of the number of actual stages and the capability of taking interstage samples. Once the operating characteristics have been determined for this system, the unit can be scaled up or down by application of principles of geometric and dynamic similitude.

The proper settling time must be provided by the settling section, and conditions for mixing must be similar. Ports must be designed for a minimum pressure drop. Under these conditions it has been possible to scale equipment successfully by a factor of 50—100.

Future plans include a program to determine the optimum mixing conditions and settling-section configurations for the unit. With optimum conditions, it is probable that higher throughputs per unit volume can be obtained without sacrifice of efficiency.

When different types of contactors are compared, there is always the problem of what basis to use for comparison. The answer to this question can be determined to some extent by the particular process being considered. One basis which is frequently used is the ratio of capacity to cross-sectional area expressed as gallons per square foot. In the case of mixer settlers, though, this basis presents the problem of what cross-sectional area should be used. Because of this difficulty, a variation of this basis has been proposed for comparing contactors (*1*). The volume occupied by the equipment is an important variable since space requirements, packing costs (if any are used), and fabrication costs are approximately proportional to the volume. Therefore, the measure of the effectiveness of a contactor can be expressed as follows:

$$E_f = K\frac{NF}{V} = K\left(\frac{1}{t_m + t_s}\right) \qquad (2)$$

For packed tower design, Equation (2) becomes

$$E_f = K\frac{NF}{(Ah + V_{\text{in}} + V_{\text{out}})}$$

$$E_f = K\frac{G}{\rho_{\text{avg}}\left(HETS + \dfrac{V_{\text{in}}}{NA} + \dfrac{V_{\text{out}}}{NA}\right)} \qquad (3)$$

A comparison of specific contactors on the basis of this equation would require data on the units involved. It can be stated in general, however, that the effectiveness of packed columns, mixer settlers, and pulse columns are in the same order of magnitude, with values in the order listed.

Acknowledgment

The authors wish to express their appreciation to B. V. Coplan and J. K. Davidson for their interest and encouragement; to W. O. Haas for technical assistance; and to Merle Jones for the analytical determinations.

Notation

A = total cross-sectional area of column, sq.ft.
$[Ac^-]_{aq}$ = concentration of acetate ion in aqueous phase
E_f = contactor effectiveness
E_g = gross distribution coefficient for acetic acid, including ions
E_{HAc} = distribution coefficient for unionized acetic acid, which may be considered constant at low concentrations
F = total flow rate, cu.ft./hr.
G = mass flow rate/unit area, lb./(hr.)(sq.ft.)
$[H^+]_{aq}$ = concentration of hydrogen ion in aqueous phase
$[HAc]_{aq}$ = concentration of unionized acetic acid in aqueous phase
$[HAc]_{org}$ = concentration of acetic acid in organic phase
$HETS$ = height equivalent to a theoretical stage, ft.
h = height of packed section, ft.
K = dimensional constant depending upon the solvent-extraction flow sheet
N = number of theoretical stages
t = holdup time/theoretical contacting, hr.
t_m = holdup time in mixing section, hr.
t_s = holdup time in settling section, hr.
V = total contactor volume, cu.ft.
V_{in} = volume of the inlet section, cu.ft.
V_{out} = volume of disengaging section, cu.ft.
ρ_{avg} = average density, lb./cu.ft.

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Presented at A.I.Ch.E. meeting, Louisville, Ky.

Map indicating location of plants milling Plateau uranium-vanadium ores. (See Table 1, page 206)

URANIUM OXIDE FROM ORES

— with six process flowsheets

Arthur Lins | Consultant, New York, N. Y.

The recovery of uranium from ores in which it is found entails many chemical engineering operations and problems, although the processes used were applied originally by mining engineers. It is for this reason that they are usually referred to as "milling processes," "metallurgical practice," and "extractive metallurgy." The chemistry of these processes has been considered classified defense information until very recently, although most of the fundamentals used are more than fifty years old.

The compilation and publication of these flowsheets has been undertaken for the purpose of giving the chemical engineer some added insight into what I believe to be an attractive field for further research and development by chemical engineers. Even at this time, the methods used and the recoveries obtained are not considered entirely satisfactory. Valuable byproducts are running to waste for lack of economic recovery methods. Many chemical engineering problems such as operational steps remain unsolved.

Part of the difficulty which faces the uranium producer is the bewildering array of uranium minerals to be found in nature. They are for the most part very complex, and even now the chemical constitution of many are not known. It is generally accepted that most uranium minerals exist in the form of pegmatites, especially those of granite pegmatite. The principal exceptions are pitchblende (which usually occurs in seams and veins), carnotite and its associated minerals, as well as uranium associated with carbonaceous matter such as Swedish oil shales. Uranium seems to have been deposited by nature from streams of hot solutions which impinged upon rocks where it underwent chemical reactions which resulted in

precipitation. Many associated elements were precipitated as sulfides, but uranium, because of its chemical properties, was nearly always deposited as an oxide. Very often, it formed more complex compounds through reaction with the compounds of other elements.

Before 1942, no operations existed for the purpose of recovering uranium alone. Uranium ores were treated mainly for the recovery of radium and vanadium. Today, more than twenty countries are known to have uranium in one or more of the many mineral forms. For the most part, they are considered economic deposits. The remainder of this paper will be confined to activities within the U. S., Canada, and Africa.

In 1942, the U. S. Army Engineers' "Manhattan Project" (later to become the U. S. Atomic Energy Commission), became the world's largest buyer of uranium. This provided the incentive for what became the uranium rush of the Colorado Plateau. In the latter half of the nineteen forties, the A.E.C. came forth with a new program for purchasing uranium. This immediately started a new rush of activity and many new plants were built and older plants rebuilt. This activity has continued up to the present time.

Table 1 lists the plants constructed for treating uranium-vanadium ores of the Colorado Plateau from 1900 to date, with a summary of their operations.

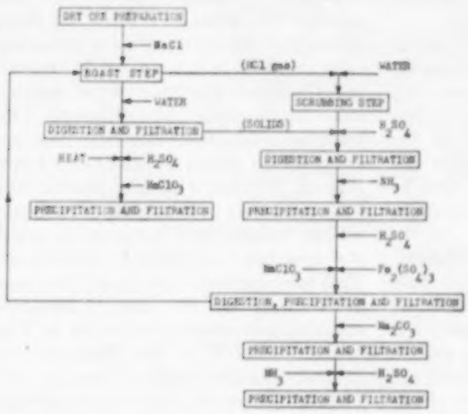
A typical salt roasting-acid leaching process is shown in Flowsheet 1, which is representative of the Rifle, Colo., plant of Union Carbide Nuclear Co. In this process a mixture of ore and sodium chloride is heated in a multiple hearth roasting furnace, followed by the extracting of the resulting complex compounds with hydrochloric and/or sulfuric acids, after which uranium and vanadium are separated from solution by precipitation.

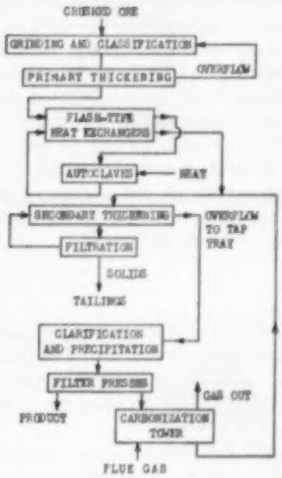
With the exception of those plants which are discarding the vanadium (mainly for the reason that they cannot as yet profitably recover it), the salt roasting process is now more or less standard for Colorado Plateau ores. This process, which employs acid and/

Table 1.—General List of Plants Constructed for Milling Plateau Uranium-Vanadium Ores

VANADIUM PLANTS	LOCATION	TYPE OF ORE	APPROXIMATE PERIOD OF OPERATIONS	TYPE PROCESS EMPLOYED
Primos Chemical Co.	Newmire, Colorado	Roscoelite	1910 to 1929, intermittently	Salt Roast
U. S. Vanadium Co.	Rifle, Colorado	"	1924 to 1932	
			1942 to 1946	" "
Vanadium Corp. of America	Naturita, Colorado	Carnotite	1926 to 1932	" "
			1938 to 1942	
International Vanadium Corp.	Dry Valley, Utah	"	1931 to 1938	" "
U. S. Vanadium Co.	Uravan, Colorado	"	1936 to 1940	" "
Blanding Mines Co.	Blanding, Utah	"	1940 to 1943, intermittently	" "
Gateway Alloys Co.	Gateway, Colorado	"	1941 to 1943	" "
U. S. Vanadium Co.	Durango, Colorado	"	1941 to 1946	" "
URANIUM AND VANADIUM PLANTS				
Poulot & Voilleque Mill	Slick Rock, Colo.	Carnotite	1900 to 1902	Carbonate leach
U. S. Vanadium Co.	Uravan, Colo.	"	1940 to 1945 1950 to date	Salt Roast & acid leach
Vanadium Corp. of America	Naturita, Colo.	"	1942 to date	Salt Roast, carbonate & acid leach
U. S. Vanadium Co. (Manhattan Project)	Uravan, Colo.	Salt Roast Tailings	1943 to 1946	Acid leach
U. S. Vanadium Co. (Manhattan Project)	Durango, Colo.	"	1943 to 1946	" "
U. S. Vanadium Co. (Manhattan Project)	Grand Junction, Colo.	Uranium-Vanadium conc.	1943 to 1946	Soda Ash roast
Vanadium Corp. of America	Monticello, Utah	Carnotite	1943 to 1946	Salt Roast & carbonate leach
U. S. Vanadium Co.	Rifle, Colo.	Carnotite & Roscoelite	1946 to date	Salt Roast & acid leach
Galigher Co. (AEC plant)	Monticello, Utah	Carnotite	1948 to date	Salt Roast & carbonate leach
Climax Uranium Co.	Grand Junction, Colo.	"	1951 to date	Salt Roast & acid leach
URANIUM, VANADIUM AND RADIUM PLANTS				
American Rare Metals Co. and others	Slick Rock, Colo.	Carnotite	1902 to 1913	Acid leach, slime recovery
Standard Chemical Co.	Uravan, Colo.	"	1910 to 1922	Slime classification
North Continent Mines Co.	Slick Rock, Colo.	"	1934 to 1942	Salt Roast, acid cure & slime recovery
URANIUM				
Vitro Uranium Co.	Salt Lake City, Utah	Carbonaceous type	1951 to date	Calcine & acid leach
Anaconda Co.	Grants, New Mexico	High limestone	1953 to date	Carbonate leach
Kerr-McGee Co.	Shiprock, New Mexico	Carnotite	1954 to date	Acid cure & IX
Uranium Reduction Co.	Moab, Utah	"	Under construction " "	Acid leach & RIP
Anaconda Co.	Grants, New Mexico	"	ready late 1955	" " " "
Mines Development Co.	Edgemont, S. D.	"	Under construction	" " " "
Trace Element Co.	Maybelle, Colo.	"	" "	" " " "
Rare Metals Co.	Cameron, Ariz.	"	" "	" " " "

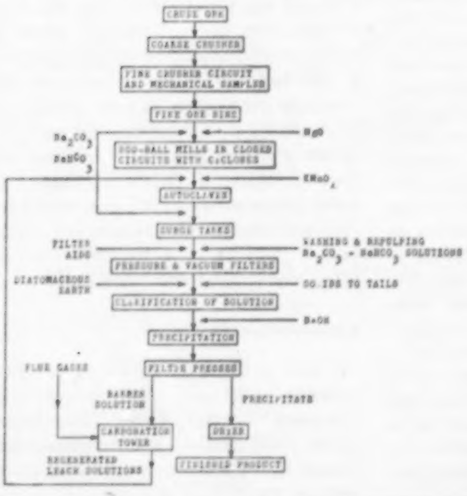
Flowsheet 1. Rifle Plant, Union Carbide Nuclear Co.



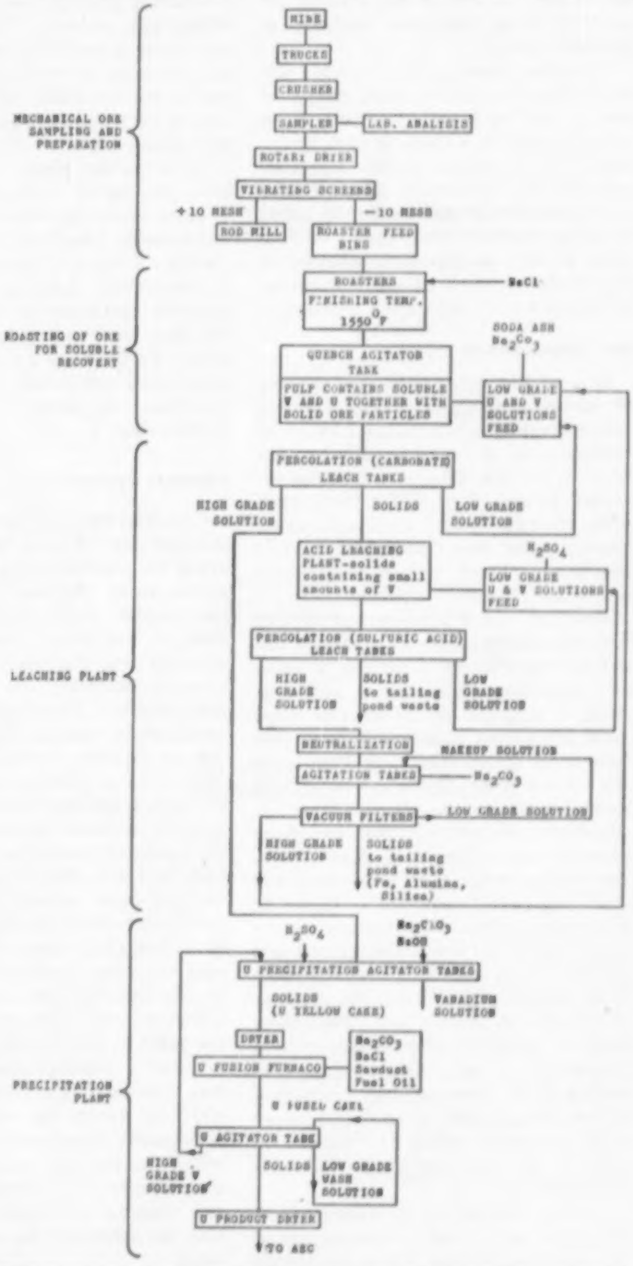


Flowsheet 5. Beaverlodge, Saskatchewan, refinery.

Flowsheet 3A. Alkaline plant.



Flowsheet 2. Durango Plant, Vanadium Corporation of America.



or alkali leaching steps for recovery of both vanadium and uranium, is shown in Flowsheet 2, which depicts the process used by Vanadium Corp. of America at their Durango, Colo. plant. The principal variable necessitating change from acid to alkali leaching steps is due to the varying of lime content of the particular ore being refined, whether it is low or high, respectively.

Many other process-altering variables exist in the composition of uranium-containing minerals of commercial importance. Included are wide variations in the ratio of vanadium to uranium and in the concentration of uranium per ton of ore. A few of the reasons for selecting those alternate methods of operation are:

Vanadium forms a water soluble salt which therefore can be easily converted into an acid or a carbonate salt which is then treated in a leaching unit. Roasting destroys organic matter and converts the iron compounds into low solubility compounds such as ferric oxide. Roasting further improves the settling rates as well as filtration behavior of the residues, which in many instances present a serious separation problem.

New Developments

One of the very latest developments in the processes used is acid leaching before roasting which makes it easier to remove some of the accompanying minerals in the ore without sacrificing recovery values. A secondary acid leach after roasting is also employed, sometimes for the same reason plus the fact that it helps break down fused particles which are formed by roasting.

Another recent development utilizes ion exchange separation. Although under investigation for a number of years for separation of vanadium and uranium, it was not until 1955 that large scale application of ion exchangers has been used on the Colorado Plateau in the newest plants. It is my belief that much benefit can arise from further applications studies of this important chemical engineering tool. A new process which at the time of writing has just come into production is shown in Flowsheet 3. This is the Anaconda process in which the ore is wet ground and classified and the thickened overflow from classifiers containing the uranium is treated with sulfuric acid. The underflow or sandy fraction is washed in a countercurrent unit; the uranium containing fines plus uranium containing filtrate are subjected to an ion exchange resin treatment which is designed to recover the uranium in a continuous operation.

Another method for recovering uranium from water solutions makes use of the fact that uranium can under certain conditions be extracted with organic compounds which act as solvents.

Processes have been and are being developed which involve a combination of chelation and liquid-liquid separation. In the production of coordination compounds the metallic ion is held in the chelation claw in a loosely bonded derivative. Such compounds can then be separated by liquid-liquid extraction with organic solvents directly, or, in some cases, the chelate is first decomposed and then subjected to extraction.

This is in use in the phosphate and phosphoric acid plants where uranium is recovered as a byproduct even though it occurs in relatively low concentration. While this procedure has been developed to an advanced state in the chemical industries by chemical engineers, its use in the extraction of uranium from ores of high concentration is now in the pilot plant stage.

In the newer plants, some of which have just started operations, vanadium is being discarded even though it does not actually lower the cost of uranium recovery if value of recovered vanadium is considered. Leaving out vanadium recovery operations of course simplifies the flow sheet and reduces the investment. To illustrate a type of operation which does not include this recovery of vanadium, the reader is again referred to Flowsheet 3.

Canadian Operations

Canadian methods for the recovery of uranium are different because the ores are of the pitchblende type. Pitchblende, as the name suggests, consists of organic matter in which minerals of uranium as well as of a number of other elements are dispersed. Some of the uranium minerals are uraninite and uranothorite. These ores contain no vanadium in amounts that warrant giving its recovery serious consideration. This form of mineral does not call for any radical changes in the general chemistry of uranium extraction, therefore the Canadian plants also have developed both acid and alkaline solutions as the two principal extraction media. Economics ultimately decides the amounts of acid or alkali required for the associated minerals, of which there is a wide variety both in types and quantities in Canadian ores. Although pitchblende is the main source so far, the Brannerite mineral, a titanium-uranium-iron complex compound, is available in quantities and now awaits the development of a commercial separation process which could recover not only uranium, but also titanium in a form suitable as a raw material for producing either or both the metal and the well known pigment.

Typical of Canadian processing (and perhaps the oldest) is the Port Hope (Ontario) Refinery, shown schematically in Flowsheet 4. Another interesting Canadian operation is at Beaverlodge in Northeast Saskatchewan. This plant uses autoclaves and flash heat exchangers as shown in schematic Flowsheet 5. The ore used is a granitic rock with a mixture of a number of minerals, mainly feldspar and hematite, in which the uranium is present as pitchblende. This improvement over straight carbonate leaching was the result of extensive research and development work by Professor Forward of the University of British Columbia and his associates. After their successful application of autoclave leaching for the recovery of cobalt, copper and nickel, they applied similar principles to both uranium and vanadium on a small scale. The process is carried out at temperatures of about 100° C. under an oxygen partial pressure of about one atmosphere, in this way converting the uranium to soluble sexivalent state. It is precipitated for recovery by converting to the oxide of the quadrivalent state by use of hydrogen plus a catalyst under pressure and heat. The details of the chemistry of this process have been fully described. (*J. Metals*, 1954, 6, 827).

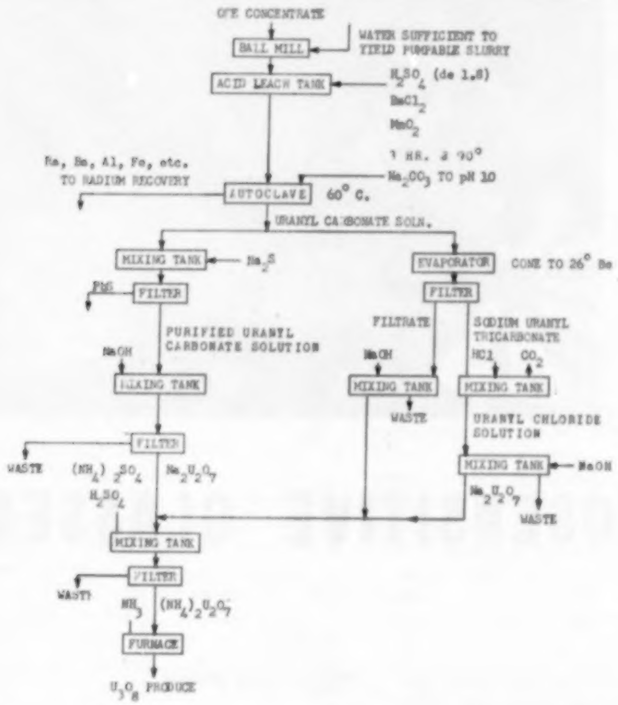
Africa

The continent of Africa produces substantial quantities of uranium. The main source, at present, is primarily pitchblende and Flowsheet 6 shows the process used.

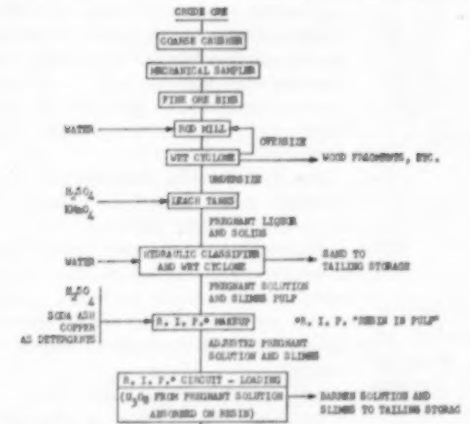
In South Africa, a number of gold mines produce uranium as a by-product. Fundamentally, the process involves, first, extraction of the gold by conventional cyanidation practice. The residue from this operation is mixed in agitator tanks with a mixture of sulfuric acid and manganese oxide (in the form of pyrolusite ore). This ore, which is mined locally, acts as an oxidizing agent, a reaction necessary to convert the uranium compound to one soluble in acid. From this point on, the recovery of the uranium from acid solution follows methods already described. In some instances, when the gold operation residues are very low in uranium, flotation is used to raise the concentration prior to chemical extraction.

Acknowledgment

I wish to thank the following for their valuable assistance: Anaconda Copper Company, Gunnar Mines Ltd., Vanadium Corporation of America, and Union Carbide Nuclear Corporation as well as the U.S. A.E.C.



Flowsheet 6. Process used for production of U_3O_8 from African pitchblende.



Flowsheet 3B. Acid plant.

Flowsheet 4. Port Hope, Ontario, refinery.

nucleation and growth of metal particles and crystals in

Fig. 1.

PHOTOSENSITIVE GLASSES

F. W. Schuler | Corning Glass Works
Corning, New York

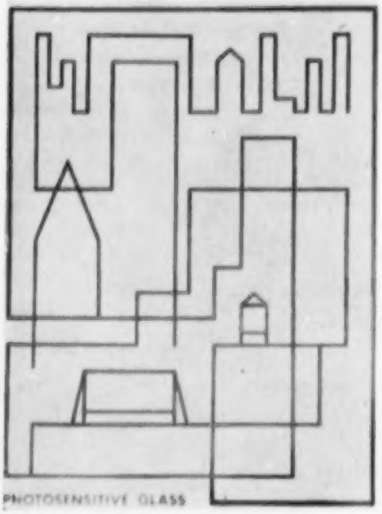
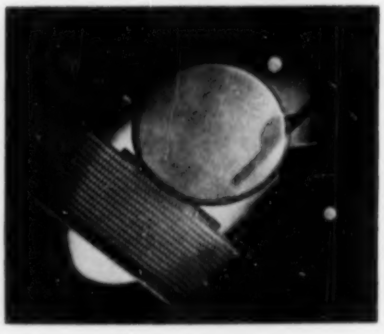


Fig. 2.

Fig. 3.



Although glasses present some problems in the study of nucleation, they are an excellent material for controlled studies of heterogeneous nucleation at elevated temperatures, especially as the state may be frozen-in by cooling and rendering the glass more viscous. By introducing metal particles of colloidal size, using photosensitive or nonphotosensitive techniques, one may nucleate the crystallization of another phase. Photosensitive glasses produce metallic particles of different size distributions depending upon the exposure and heat treatment, and these size distributions have effects upon nucleation. Variations in composition affect the photosensitivity, the crystalline phase, and the viscosity-temperature relationship and introduce endless variations in the studies.

In general, crystallization or devitrification in glasses should be avoided. In the melting process, the tank temperatures are maintained above the liquidus temperature, that temperature below which crystallization can take place. As the glass is undercooled below the liquidus temperature, there are maxima in both the rate of formation of nuclei (that is, the spontaneous appearance of nuclei) and in the rate of crystal growth. Both factors are reduced to negligible values upon further undercooling, as the viscosity of the melt increases rapidly. Consequently, in forming glasses, one holds the glass for a minimum time in this temperature region of maximum crystallization rate, and also devises compositions which have only a slight tendency to devitrify.

Photosensitive Glasses

Photosensitive glasses make use of crystallization, instead of avoiding it, and it is hoped that commercial uses will result. There are two main types of photosensitive glasses: (1) those in which colloidal particles are formed after exposure and development, producing colors, and (2) those in which these particles nucleate the crystallization of another phase. Both types produce two-dimensional images extending into the depth of the glass and showing differential properties with respect to the unexposed regions.

Figure 1 shows a photosensitive glass in which colors have been produced by the colloidal metal particles.

Figure 2 shows another type of photosensitive glass in which the colloidal metal particles have nucleated another phase, sodium fluoride (NaF) crystallizing and producing a region of opacity.

Still another type (see Figure 3) shows that use is made of the differential solubility for "chemical machining" of intricate details.

Furthermore, upon proper development after an over-all exposure of some object shaped by glass-working techniques, a uniform semicrystalline material can be made from the glass, and this material may have greatly increased strength.

DETAILS OF PHOTOSENSITIVE GLASSES

These glasses, which are silicate glasses containing alkalies, alkaline earths, aluminum oxide, and zinc oxide,

also contain an optical sensitizer and photoactive materials. This photosensitizer is Ce^{+3}, which absorbs ultraviolet radiation at 3,130 A and the photoactive agents are gold, silver, or copper. The oxidation state must be carefully controlled, both by the melting temperatures and the addition of oxidizing or reducing agents. There is evidence that the gold or silver does not exist completely as Au^{+} and Ag^{+}, but that some of it is reduced, and this reduction may be necessary to produce centers or nuclei for the subsequent growth of colloidal particles, which might follow the basic photosensitive process:

$$Ce^{+3} + h\nu \rightarrow Ce^{+4} + e^{-} \quad (1)$$

$$e^{-} + Au^{+} \rightarrow Au^{\circ} \quad (2)$$

Equations (1) and (2) are shown in Figure 4. After exposure, a colorless latent image is produced and this is considered the absorption of radiation by the Ce^{+3} followed by the emission of photoelectrons, which are trapped in centers adjacent to the parent ion. Development by heating to 600° C. for 2 hr., for example, permits the capture of the electrons by the metal ions with the subsequent growth to colloidal-sized particles.

Rapid heating to elevated temperatures destroys the latent image and this destruction is accompanied by thermoluminescence, which is probably the recapture of the trapped electron by the Ce^{+4} and the emission of a quantum. Nucleation at an intermediate temperature fixes the latent image permanently, although no color is produced. Once the glass has been properly nucleated, further development depends upon the temperature and time.

The time-temperature relationship for a so-called *normal* development, in which one tries to get the same degree of development or the same completeness of the process, is shown in Figure 5.

Nonphotosensitive Techniques for Producing Metal Particles in Glasses

It is quite simple to produce free metal by incorporating higher concentrations of gold and silver compound into the batch materials than are used in the photosensitive glasses, or by adding platinum compounds and, consequently, to be able to nucleate another phase. However, one would lose the ability to produce patterns which might show differential effects.

Nucleation and Growth of Crystalline Phases

As mentioned previously, crystallization can take place in a glass without introducing metal particles to nucleate the crystalline phase.

Figure 6, from Eitel's book "The Physical Chemistry of the Silicates" (*1*), shows the rate of formation of nuclei and the rate of crystal growth as a function of the undercooling temperature. The maxima of these two curves need not coincide; in fact, the curve for the formation of nuclei might be at a larger undercooling temperature, so that one would cool and then reheat to get rapid growth of crystals as is done in the "striking" of some colored glasses and opals.

The nucleation phenomena are more easily observed in the second type of photosensitive glass, that which produces a crystalline phase, rather than in the type which produces just colloidal metal particles. The type which produces crystals of lithium metasilicate, which etches differentially in hydrofluoric acid compared to the unexposed glass, is especially suited for study. In such a glass one can measure the depth of etch under some standard etching conditions.

Figure 7 shows a depth of etch curve as a function of exposure. One must first obtain numbers which characterize the sensitivity of the glass, and thus study the effect of concentration of gold, silver, melting temperatures, and concentration of oxidizing agent. By developing and nucleating at different temperatures and then etching, one can study the effect of the temperature on the rate of growth of crystals.

In general, one finds that the temperatures to nucleate the crystals with the metal particles are generally different from the temperatures at which the crystals grow rapidly.

A generalized heat cycle for processing a photosensitive glass which produces a crystalline phase is depicted in Figure 8. One can study the development after exposing at different temperatures, with or without cooling to room temperature, with slow heating or rapid heating, and with or without cooling in the middle of the development cycle.

Metal particles, too small to cause nucleation at the development temperatures, can be formed under some condi-

GENERALIZED HEAT CYCLE FOR PROCESSING PHOTOSENSITIVE GLASS

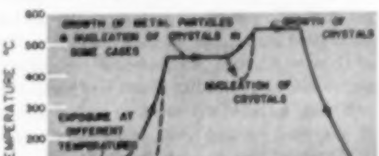


Fig. 8.

theory

1. BASIC PHOTOSENSITIVE PROCESS:

$$Ce^{+3} + h\nu \rightarrow Ce^{+4} + e$$

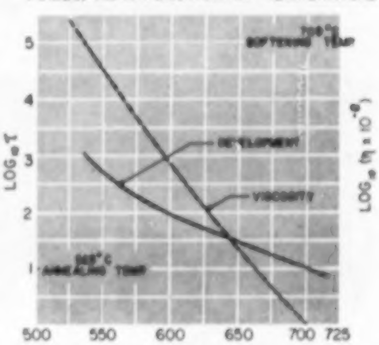
$$e^{-} + Au^{+} \rightarrow Au^{\circ}$$

2. THERMOLUMINESCENCE WITH RAPID HEATING:

$$Ce^{+4} + e^{-} \rightarrow Ce^{+3} + h\nu'$$

Fig. 4.

PHOTOSENSITIVE GLASS. TIME (T IN MINUTES) FOR "NORMAL" DEVELOPMENT AND VISCOSITY (η IN POISES) AS A FUNCTION OF TEMPERATURE



FROM S D STOOKEY · INDUSTRIAL AND ENGINEERING CHEMISTRY VOL. 41 856 FF APRIL 1949

Fig. 5.

RATE OF NUCLEI FORMATION AND RATE OF CRYSTAL GROWTH AS A FUNCTION OF UNDERCOOLING

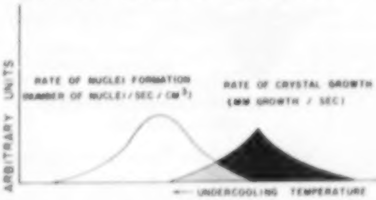


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Fig. 6.

DEPTH OF ETCH VS EXPOSURE

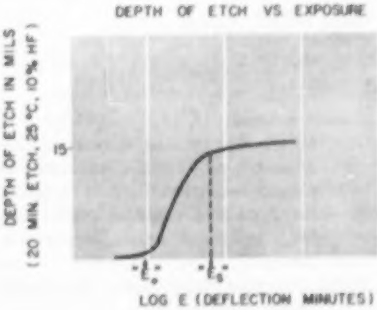

Fig. 7.

tions, for example, at the longer exposures and, consequently, the glass will etch poorly. Figure 9 illustrates how there is less crystalline phase at the longer exposures and therefore less etching, but it also demonstrates that a development cycle with cooling can give better nucleation. These phenomena fit into Turnbull's theories of nucleation (*3*).

Figure 10 shows a hypothesized crystal embryo size distribution and the critical sizes for nucleation, and the metal particle size distribution which can vary with different exposure. By sufficient undercooling, one can go to a new temperature where the critical size embryo of the crystal is smaller than the metal particles produced by the photosensitive process and thus get nucleation of the crystal phase.

INCREASE IN CRYSTALLINE PHASE BY COOLING DURING THE DEVELOPMENT CYCLE

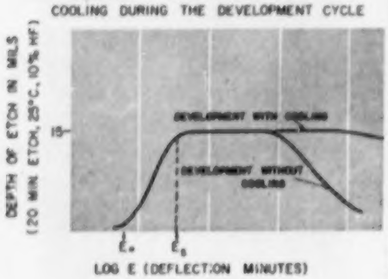

Fig. 9.

SCHEMATIC DRAWING

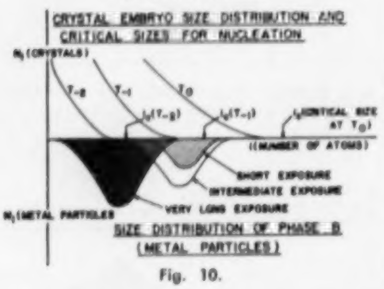

Fig. 10.

As in the gold glass, one may develop these glasses which etch to the same degree at elevated temperatures. In such a case the rate constant, k, is inversely proportional to the development time and one may associate an activation energy with the development process which is about 45,000 cal./mole, and can thus appear to be related to diffusion processes.

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2. Fisher, J. C., J. H. Holloman, and D. Turnbull, *J. Applied Physics*, **19**, 775-78 (1948).
3. Turnbull, D., *J. Chem. Physics*, **18**, 198-203 (1950).

Presented at A.I.Ch.E. meeting, Houston, Texas.

What's in

Symposium Series Volume 50

(Series 15—"Mineral Engineering Techniques")

Fundamentals and Applications of the Liquid Cyclone

Donald A. Dahlstrom

Although the first industrial installations of the liquid cyclone in the United States occurred only about five years ago, undoubtedly several thousand are in operation today. Four reasons are primarily responsible for this rapid acceptance—economy, simplicity, highest capacity per unit of floor space, and ability to perform a relatively sharp classification at very fine particle sizes. The fields of application are varied but the majority to date are mined products such as coal, phosphates, clays, sand, and the metallic ores.

Magnetic, High-Tension, and Electrostatic Separation

Alan Stanley

The original method no doubt of separating economic minerals from waste minerals was hand picking of desired minerals from the undesired ones; however, as man relied more and more upon machines and other men for various necessities of life, the old methods of mineral concentration became uneconomic because of the expense of manpower and the uncooperativeness of nature in not creating large amounts of high-grade minerals in desired places and amounts. Man therefore was forced to find methods of economically treating large quantities of material to recover small amounts of desired minerals.

A Progress Report on Heavy-Media Separation

S. A. Falconer

An important development in the field of ore beneficiation is the process now commonly known as heavy-media separation. This paper presents a brief description of this process and reviews the progress made in its application. In general, heavy-media separation processes will treat any ore in which the valuable mineral constituents have an appreciable difference in specific gravity from the worthless gangue. Essential steps in heavy-media separation processes are (1) preparation of the feed, (2) heavy-media separation, (3) removal of medium from the separated products, and (4) reclamation and cleaning of the medium for reuse. Operating costs of heavy-media separation plants are low because the efficiency of the process itself as well as of the various units required in its operation make for a compact plant with minimum space requirements.

Some Factors to Consider in the Application of Sink-Float Separation

Carl S. Westerberg

Three types of media are used in sink-float work: (1) magnetic media using magnetite, ferrosilicon, or mixtures of the two; (2) mineral media using clays, sand pyrite, barite, galena, loess, and gypsum with water; and (3) chemical media including solutions of calcium chloride or organic liquids. Selection of the medium to be used is based on cost and the necessary operating gravity. In summary the general aspects of sink-float applications have been reviewed to point out some factors to be considered for possible applications in the chemical field. It is believed that with experiences gained in the past and a sound knowledge of the principles involved, equipment manufacturers can engineer and build complete units for new applications of the process.

Use of Chemical Reagents for Classification and Settling

G. Gutzeit and C. C. Coscia

The theory and factors affecting the phenomenon of flocculation and dispersion are presented along with a method for determining the electrical charge present. Examples are given illustrating their use in thickening and filtration operations. Uses include hydroseparation and flotation.

Vibrating Screens with Straight-Line Motion

Peter V. Mancini

Vibrating screens are available under a variety of trade names; however fundamentally there are only two types, those in which points on the screening surface reciprocate over substantially rectilinear paths, that is, straight-line motion screens, and those in which the paths are closed and either nearly circular or pronouncedly elliptical in general outline. This paper discusses straight-line vibrating screens.

Hydraulic Classification

Elliott J. Roberts

Hydraulic classification is a unit operation often used in close conjunction with other concentrating devices; in Minnesota a substantial number of hydraulic classifiers are producing finished concentrates of iron ore. Applications include the following: iron ore; phosphate rock; table feed preparation; closed-circuit grinding; etc.

(To be continued)

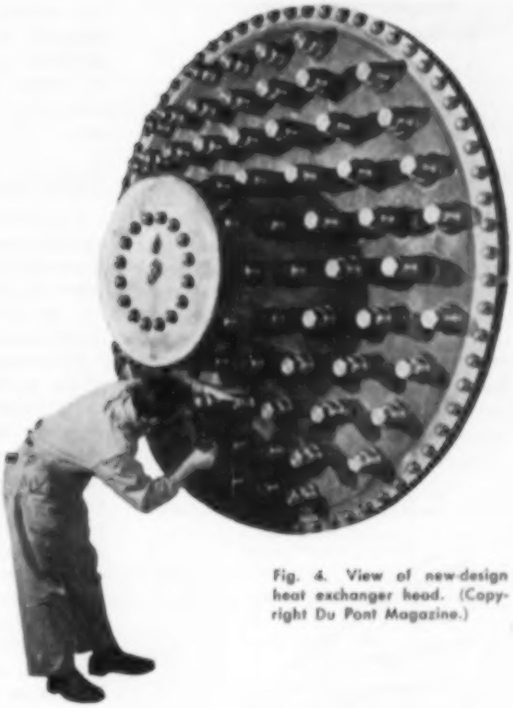


Fig. 4. View of new-design heat exchanger head. (Copyright Du Pont Magazine.)

A novel head design for shell-and-tube heat exchangers is presented. The design incorporates features of low holdup, low pressure drop, and good flow distribution among the tubes. A comparison is made with alternate head designs. Information is also presented on the determination of the head pressure drop and the reduction in heat-exchanger effectiveness due to flow unbalance.

design of
HEAT EXCHANGER HEADS FOR LOW HOLDUP

M. T. Cichelli and D. F. Boucher | E. I. du Pont de Nemours & Co., Inc., Wilmington, Delaware

Large-scale heat exchangers are required for cooling process fluids at many nuclear reactor installations. In many such heat-exchanger installations the process fluid is costly, and an appreciable contribution to the over-all savings can be effected by a reduction in head volume from that associated with conventional designs.* The high cost of the process fluid usually results in the use of small line sizes and thus high liquid velocities. In turn, it becomes necessary to take special steps to minimize the heat-exchanger head pressure drop and to ensure uniform flow among the tubes. A novel head design is necessary to fulfill these requirements. This paper presents the analysis which led to the solution of the problem.

Design Requirements

LOW HOLDUP

Holdup must be as low as is consistent with good flow distribution and low pressure drop. A head of constant depth of only 9 in. between cover and tube sheet would have a holdup volume of 25.5 cu.ft. A holdup of 9 cu.ft. per head was the goal of the contemplated design.

GOOD FLOW DISTRIBUTION

Good flow distribution among the tubes is needed because unequal flow results in reduced heat-exchanger effectiveness, which is reflected in reduced productivity under certain conditions. With an unfavorable design, the resulting reduction in productivity could be very costly.

LOW PRESSURE DROP

Pressure drop due to friction and kinetic energy losses in the heat-exchanger head should be kept as low as possible so as to minimize over-all pumping costs. Kinetic energy effects are large in these installations because of the high liquid velocities in the pipe lines before and after the exchangers.

ADEQUATE MECHANICAL STRENGTH

Design for adequate mechanical strength is always an essential aspect of the problem. This paper, however, does not go into this part of the problem, but is restricted to the process aspects of the design.

The relatively high liquid velocities used in the heads require that consideration be given to the possibility of failure due to vibration actuated by fluid flow.

General Theoretical Considerations

UNEQUAL FLOW AMONG TUBES

Unequal flow among tubes in the heat exchanger is caused by differences between the pressure drop across some tubes and that across others. This unequal flow reduces heat-exchanger effectiveness in the manner described in Appendix *A* and, as mentioned above, can appreciably increase cost per unit of productivity.

To estimate the economic significance of flow unbalance among the heat-exchanger tubes, the following procedure was used. Where a calculated unbalance was found, the heat-exchanger tubes were divided into two groups, those of higher and those of lower flow rate. The average flow rate for each group was then determined, and the reduction in

* A treatment of the economics of the over-all design of shell-and-tube heat exchangers is presented in reference 2.

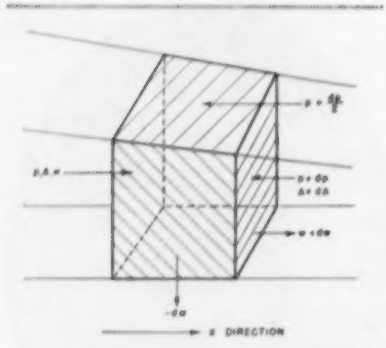


Fig. 1. Force and mass balance on an element of volume.

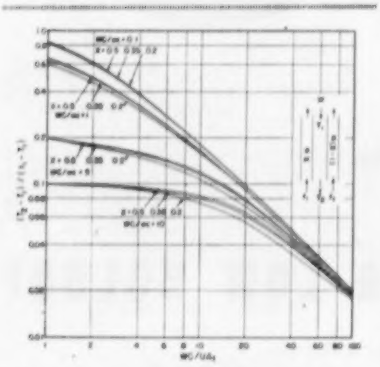


Fig. 1A. Theoretical effect of process fluid maldistribution in counter-current heat transfer.

Fig. 1B. Heat exchanger head outline showing sections for friction loss and pressure drop calculations.

heat-exchanger effectiveness was the reduction in the value of the ordinate shown on Figure 1A. In effect Figure 1A yields a relationship between the heat-exchanger outlet and inlet temperatures.

HEAD PRESSURE-DROP RELATIONS

Two factors relating to the fluid mechanics of head design cause unequal pressure drop across the heat-exchanger tubes: (1) friction loss in the heads and (2) uncompensated pressure variations due to momentum changes in the heads.

Friction loss in the heads is a result of the lateral flow of the process fluid as it feeds the heat-exchanger tubes. Pressure variations due to momentum changes have two sources. The first is the Bernoulli effect, where a velocity change in a fluid stream is accompanied by a corresponding pressure change. The second source is the momentum transfer that occurs as fluid leaves the main flow stream and enters a side tube. Part of the x component of momentum of the stream making the right-angled turn into the tubes is given up to the balance of the stream flowing past the tube within the head. Data of other investigators indicate that the extent of this momentum transfer to the header fluid is generally less than the maximum theoretical (*3, 4, 5, 8, 11*). For simplicity and conservatism in computing the pressure changes due to momentum transfer, 100% effectiveness of transfer was assumed. A corollary situation exists in the outlet head. In this case, in order to develop the lateral component of momentum of fluid issuing from the tubes, additional upstream pressure is required in the fluid flowing across the head.

An appreciable pressure unbalance due to momentum transfer may also be occasioned by the turning flow of the main fluid stream as it enters the inlet head and leaves the outlet head. It is assumed that this is eliminated by the use of appropriate baffle plates or deflectors in the heads.

A force balance will be used to show the basis for the general equation for pressure change in a channel of varying cross section with side drawoff. In Figure 1 two x-directed forces are exerted on the shaded element of volume, and by Newton's law of motion their sum equals the rate of change of momentum of the fluid. The two forces are expressed mathematically below.

1. *Pressure × Area (7)*

$$\vec{F}_p = pA - (p + dp)(A + dA) - \left(p + \frac{dp}{2}\right)(-dA) \cong -A\,dp \qquad (1)$$

2. *Friction.* The Fanning friction equation can be written as follows for this case:

$$\vec{F}_f = -\left[\left(\frac{4f}{D_h}\right)\left(\frac{\rho V^2}{2g_c}\right) dL \left(A + \frac{dA}{2}\right)\right] \cong -\frac{2f}{D_h}\frac{w^2}{\rho A g_c}\,dL \qquad (2)$$

The sum of these two forces equals the rate of change of momentum.

$$\vec{F}_p + \vec{F}_f = \frac{d(mV)}{g_c d\theta} = \frac{m}{g_c}\frac{dV}{d\theta} + \frac{V}{g_c}\frac{dm}{d\theta}$$

But

$$m = w\Delta\theta$$

Therefore

$$F_p + F_f = \frac{w}{g_c}dV + \frac{V}{g_c}dw = \frac{d(wV)}{g_c} \qquad (3)$$

Substituting for F_p and F_f, dividing through by A, and transposing dp to one side of the resulting equation yields the following general equation for pressure variation across a head of any geometry:

$$dp = -\frac{d(wV)}{g_c A} - \frac{2fw^2}{D_h \rho A^2 g_c}\,dL \qquad (4)$$

This equation may be solved for each of the head designs considered and the variation in pressure across the inlet and outlet heads calculated therefrom. Since in the cases considered (wV) decreases in the direction of flow, the first term on the right side of Equation (4) is positive. The second term is negative.

Appendix *B* shows the integrated equation for the head design that was finally selected for the problem under consideration. Calculations reveal that the friction-loss term on the right-hand side of Equation (4) is less than 20% of the momentum term in this case. The relative unimportance of the friction-loss term in determining pressure distribution in a head applies to all the designs considered. Consequently, in the analysis that follows, consideration will be given only to the momentum-transfer term.

Comparison of Alternate Designs

The four head designs shown in Figure 2 will be considered in turn. The equation

$$dp = -\frac{d(wV)}{Ag_c} \qquad (5)$$

obtained by dropping the friction term from Equation (4), will be integrated for each case. It is assumed that flow is withdrawn uniformly per unit-head area for the calculation of the pressure

change due to momentum effects. Actual flow variation among the tubes will in general be small, and this approximation enables the use of integral calculus to solve Equation (5).

RADIAL FLOW, CONSTANT DEPTH

$$\Delta p = -\frac{1}{g_c}\int \frac{d(wV)}{A}$$

$$= -\frac{1}{\rho g_c}\int \frac{1}{A}\, d\left(\frac{w^2}{A}\right) \qquad (6)$$

When $w = w_1$ at $r = r_1$ and $w = 0$ at $r = R$ (r_1 = radius of base of deflector),

$$\frac{w}{w_1} = \frac{R^2 - r^2}{R^2 - r_1^2} \qquad (7)$$

Also,

$$A = 2\pi r z \qquad (8)$$

Therefore Equation (6) becomes

$$\Delta p = -\frac{1}{\rho g_c}\int \frac{1}{4\pi^2 z^2 r}$$

$$d\left[\frac{w_1^2\left(\frac{R^4}{r} - 2rR^2 + r^3\right)}{(R^2 - r_1^2)^2}\right] \qquad (9)$$

or

$$\Delta p = -\frac{w_1^2}{4\pi^2 z^2 \rho g_c (R^2 - r_1^2)^2}$$

$$\int_{r_1}^{R}\left(-\frac{R^4}{r^3} - \frac{2R^2}{r} + 3r\right) dr$$

On integration,

$$\Delta p = -\frac{w_1^2}{4\pi^2 z^2 \rho g_c (R^2 - r_1^2)^2}$$

$$\left[\frac{R^2}{2} - \frac{R^4}{2r_1^2} + 2R^2 \ln\frac{r_1}{R} + \frac{3}{2}(R^2 - r_1^2)\right] \qquad (10)$$

For example, if r_1 equals $R/4$, Equation (10) reduces to

$$\Delta p = \frac{w_1^2}{4\pi^2 z^2 \rho g_c R^4}\,[10.0\ R^2]$$

$$= 1.25\left(\frac{\rho V_1^2}{2g_c}\right) = 1.25\ V.H. \qquad (11)$$

The pressure unbalance due to the momentum-force balance is therefore relatively small and equal to about 1¼ velocity heads based on the velocity at $r = r_1$. In addition, the momentum unbalance in one head is compensated in the other head. A schematic plot of the pressure variation across the two heads is shown beside the drawings in Figure 2A. The principal disadvantages of this design are the high liquid holdup and the large pressure loss due to the right-angle turn of the liquid stream entering the head.

LATERAL FLOW, CONSTANT DEPTH

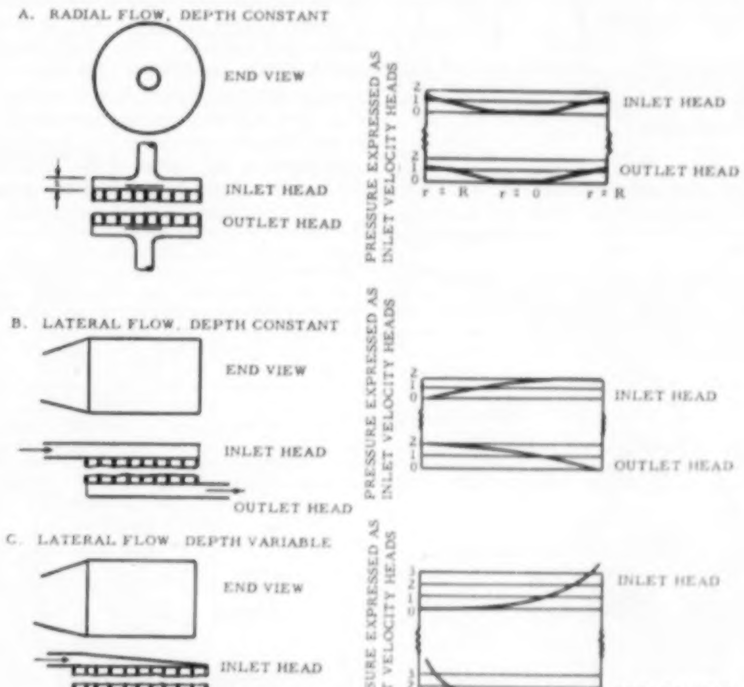
Because of the arrangement of the equipment, some economy of holdup in external piping could be achieved by use of a side-entry head. In addition, the sharp right-angled turn of the main body of the liquid stream is eliminated. (*See* Figure 2B.)

In this case A is constant and Equation (5) may be solved as follows:

$$\Delta p = -\frac{\rho}{g_c}\int_{V_1}^{0} d(V^2) = \frac{\rho V_1^2}{g_c} = 2\ V.H. \qquad (12)$$

In the inlet head the pressure at the farthest tubes is two inlet velocity heads higher than at the nearest tubes. In the exit head the pressure at the tubes farthest from the outlet pipe is higher by two velocity heads than at the tubes adjacent to the outlet pipe. The flow path, therefore, results in an uncompensated pressure change due to momentum effects, with a maximum unbalance of four inlet velocity heads. In addition, the holdup in the head would be about the same as for case A, described above, and, therefore, excessive.

Fig. 2. Theoretical head pressure distribution due to momentum transfer.



LATERAL FLOW, DEPTH VARIABLE

To conserve holdup, a lateral-flow, wedge-shaped channel may be considered, as shown in Figure 2C. In this case

$$\frac{z}{z_1} = \left(\frac{L_R - L}{L_R}\right) \tag{13}$$

$$\frac{w}{w_1} = \left(\frac{L_R - L}{L_R}\right) \tag{14}$$

and

$$A = bz \tag{15}$$

$$\Delta p = -\int \frac{d(wV)}{Ag_c}$$

$$= -\frac{1}{g_c\rho}\int \frac{d\left(\frac{w^2}{A}\right)}{A} \tag{16}$$

Substituting (13), (14), and (15) into (16) yields

$$\Delta p = -\frac{w_1^2}{g_c\rho b^2 z_1^2}\int_{L=0}^{L=L_R} \frac{1}{\left(\frac{L_R - L}{L_R}\right)} d\left(\frac{L_R - L}{L_R}\right) \tag{17}$$

Solving gives

$$\Delta p = -\frac{w_1^2}{g_c\rho b^2 z_1^2}\ln 0 = \infty \tag{18}$$

This unusual result states that an infinite pressure rise is theoretically predicted for the inlet head if constant drawoff through the tubes per unit-head area is maintained. Of course, in the actual case the momentum transfer to the head fluid would be less than perfect, and the higher pressure for the farthest tubes would influence the velocity- and flow-rate distribution within the head. The reason for the result is evident, however, from an inspection of Equation (5). The change in pressure for each row of tubes approaches infinity because V stays constant, w changes by a finite amount per unit area of tube sheet, and A, the cross-sectional area for flow, approaches zero.

RADIAL FLOW, AREA CONSTANT

Since a radial-flow head results in a compensating pressure unbalance owing to momentum effects, consideration was given to means for appreciably reducing the holdup and the sharp right-angled turn while still maintaining a moderate pressure change in either head due to momentum effects. The radial-flow head, shown in Figure 2D and in greater detail in Figure 3, accomplishes this. In this head a constant area normal to the tube sheet is maintained from the feed point at the center of the head to the outside. For calculation of the pressure change due to momentum transfer, Equations (6), (7), and (8) apply. However, in this case rz, and therefore A, is maintained constant. Equation (6) is readily integrated as follows:

$$\Delta p = -\frac{1}{g_c}\int \frac{d(wV)}{A}$$

$$= -\frac{\rho}{g_c}\int_{V_1}^{0} d(V^2) = \frac{\rho V_1^2}{g_c} = 2\ V.H. \tag{19}$$

As in the lateral-flow head with constant cross-sectional area, the pressure rise is two inlet velocity heads (based on the velocity at $r = r_1$). This pressure change is compensated by a corresponding change in the outlet head as shown in Figure 2D.

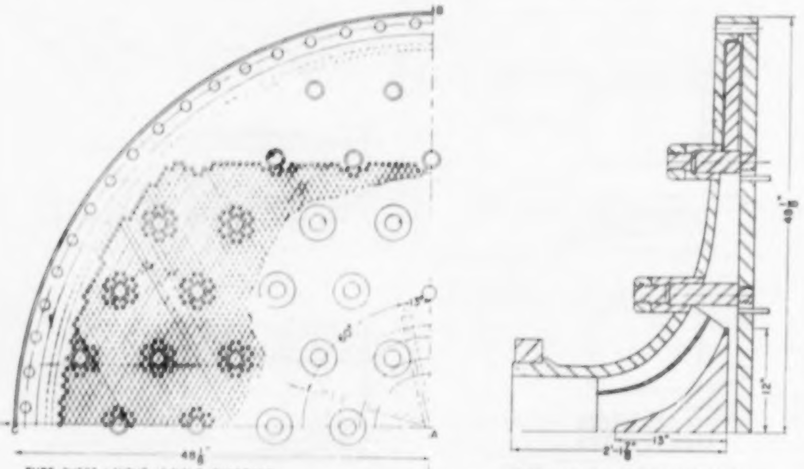


Fig. 3. Heat exchanger head details.

Details of Final Design

The main features of the final head design, as shown in Figure 3, were (1) a streamline deflector to turn the main flow stream and reduce holdup volume, (2) a splitter vane and radial vanes in the region of turning flow to prevent losses due to separation, and (3) an approximately constant area of channel normal to flow at any radius beyond the deflector piece. Because of the high velocity in the entry and exit lines, a maximum velocity of 30% of the pipeline velocity was selected for the radial flow in the head at the edge of the deflector. A 2-ft.-diam. shaped deflector was selected (the inlet and exit pipes are 1 ft. in diameter), and a 1-in. clearance provided between the bottom of the deflector and the tube sheet beneath it. Beyond the edge of the deflector the flow is essentially parallel to the tube sheet, and to maintain a constant area normal to the flow at any radius, Equation (8) shows that rz must be set equal to a constant. This is the equation of a rectangular hyperbola, where the ordinate is the pipe axis and the abscissa is a line lying in the plane of the tube-sheet surface. Consequently, in the region of the head beyond the deflector piece the head cover is a surface of revolution generated by rotating a rectangular hyperbola about the pipe axis. As there are no tubes beyond the baffle cutoff, the flow is not perfectly radial, but this factor was not believed to be important enough to warrant modifying the shape of the head. Figure 3 shows the details of the final head design. The dimensions in Table 1 were selected in order to achieve a head volume of less than 9 cu. ft. and to meet the other requirements listed above.

For mechanical strength, stay bolts were used to position the head cover with respect to the tube sheet. These

were located 12 tube-pitches apart on a triangular spacing.

In the design of the contours for the region of the turn of the main stream as it enters the head, it was important to minimize pressure loss. Consideration has been given to this problem by a number of investigators, for example, (*1* and *12*). In a high-velocity stream, pressure losses due to ordinary wall friction are generally small in comparison with losses due to sudden expansions, contractions, velocity changes, and separation of the flow stream from the wall. Consequently, the use of additional surface in the form of guide vanes to reduce the likelihood of separation in the region of turning and diverging flow was considered highly desirable. This principle is used successfully in elbows (*1*) and in straight diverging channels (*10*), where splitter vanes are used to reduce losses. A single splitter vane and six radial vanes were installed in the head, as shown in Figure 3. The splitter vane, which served to reduce the "radius ratio" for the turn and thereby to reduce separation resulting from the turning flow, was positioned so as to divide the flow channel into two equal parts. The number of radial vanes was selected to achieve a rate of increase in area along each turning and diverging channel which would not exceed the rate of increase in area for a straight-axis conical channel having a total included angle of 7°. This angle is recommended (*10*) to avoid separation in diverging flow.

The final head design resulted in a holdup volume of 8.9 cu.ft., a calculated pressure loss of 0.4 inlet-pipe velocity heads for the two heads combined, and a calculated maximum unbalance in pressure drop across the tubes of 1%. The corresponding loss in heat-exchanger effectiveness was computed to be 0.007%.

Test Results on Full-scale Unit

Experiments carried out on a full-scale heat exchanger demonstrated the adequacy of the design from the standpoints of mechanical strength, freedom from vibration, and over-all pressure drop. Subsequent operation in the plant has been trouble free, and the expected savings due to reduced inventory of process fluid, reduced power for pumping, and improved heat-exchanger effectiveness were realized. A view of the heat-exchanger head is shown in Figure 4 on page 213.

Acknowledgment

The authors wish to acknowledge the work of M. S. Brinn, who solved the equations in Appendix *A* and developed the chart shown in Figure 1A.

Table 1.—Design Dimensions, Heat-exchanger Head

Range of r, ft.	Values of z_o, $(\Delta z)_d$, $(\Delta z)_o$ at any r
$0 < r < 0.5$	$(\Delta z)_d = \frac{0.455}{r + 0.34} - 0.32$
$0.5 < r < 1.0$	$(\Delta z)_d = \frac{0.455}{r + 0.34} - 0.32$
	$(\Delta z)_o = \frac{0.455}{r}$
	$z_o = 0.083 + (\Delta z)_d + (\Delta z)_o$
	$= 0.455\left(\frac{1}{r + 0.34} + \frac{1}{r}\right) - 0.24$
$1.5 < r < R$	$z_o = \Delta z_o = \frac{0.455}{r}$
$1.0 < r < 1.5$	$z_o =$ "faired" in

z_o = vertical distance from tube sheet to head cover, ft.

$(\Delta z)_d$ = vertical thickness of deflector at any radius r, ft.

$(\Delta z)_o$ = vertical height of channel through which the main stream flows, at any radius r, ft.

Appendix A

EFFECT OF MALDISTRIBUTION IN COUNTERCURRENT HEAT TRANSFER

The effect of maldistribution of the tube-side fluid in a countercurrent shell-and-tube heat exchanger was determined for the hypothetical case where a fraction x of the fluid flows through one half the tubes and the fraction $1 - x$ flows through the other half. The shell-side fluid was assumed to be completely mixed at any cross section as it passed through the exchanger. The major resistance to heat transfer was assumed to occur on the shell side; that is, the over-all heat transfer coefficient was assumed constant. The basic heat balance and rate equations are

Heat Balance

$$xwcdt_x + (1 - x)wcdt_{1-x} = WCdT \quad (A\text{-}1)$$

Total Rate Equation

$$U(T - t_x)dA_x + U(T - t_{1-x})dA_x = WCdT \quad (A\text{-}2)$$

Individual Rate Equations

$$U(T - t_x)dA_x = xwcdt_x \quad (A\text{-}3)$$

$$U(T - t_{1-x})dA_x = (1 - x)wcdt_{1-x}$$

These equations were combined to obtain a differential equation containing T and A_x as the only variables. The resulting equation was a third-order, linear one which could be solved. The boundary conditions are

1. At $A_x = 0$, $t_x = t_1 = t_{1-x}$
2. At $A_x = 0$, $T = T_1$

The final equations are presented graphically in Figure 1A.

Appendix B

ESTIMATION OF FRICTION LOSS AND PRESSURE DROP FOR FLOW THROUGH HEAT-EXCHANGER HEADS

The friction loss for flow through both the inlet and outlet heat-exchanger heads was estimated by dividing the heads into appropriate sections as shown in Figure 1B (page 214) and analyzing each section as follows:

Section 1

INLET HEAD: For the inlet head the flow undergoes an abrupt contraction at this point. The friction loss is given by

$$(\Delta h_t)_1 = (K_t)_1(V_1^2/2g_c) \quad (B\text{-}1)$$

The contraction coefficient is given as a function of the area ratio A_1/A_o (*10a*).

OUTLET HEAD: For the outlet head the flow undergoes an abrupt expansion at this point, and the friction loss is given by

$$(\Delta h_e)_1 = \left(1 - \frac{A_1}{A_o}\right)^2 (V_1^2/2g_c) \quad (B\text{-}2)$$

Section 2

For both the inlet and outlet heads the expansion or contraction in this region is sufficiently gradual so that the only losses will be due to wall friction and the bend effect. This combination can be approximated by treating the curved flow channel as a portion of a smooth 90° elbow. The channel is first divided into about five segments of equal length and then the loss is determined for each interval as though it were a complete 90° bend by use of the average velocity and radius of curvature for that segment as follows:

$$\Delta h_{2,1} = K_{2,1}(V_{2,1}^2/2g_c) \quad (B\text{-}3)$$

The average Δh_2 is then obtained for the five segments, and a correction applied as the channel does not describe a full 90°.

$$\Delta h_2 = (\Delta h_2)_{avg.}\,(2L_2/\pi R_2') \qquad (B\text{-}4)$$

Section 3

INLET HEAD: For the inlet head the loss at this section can be taken as an abrupt expansion loss,

$$(\Delta h_i)_2 = \left(1 - \frac{A_2}{A_2'}\right)^2 (V_2^2/2g_c) \qquad (B\text{-}5)$$

OUTLET HEAD: For the outlet head, the loss is taken to be an abrupt contraction loss,

$$(\Delta h_o)_2 = (K_o)_2(V_2^2/2g_c) \qquad (B\text{-}6)$$

Section 4

This section is characterized by constant cross-sectional area for flow with either fluid withdrawal or addition. The pressure change in this section is described by the following equations. [*See* (*6a*).]

$$\frac{d(wV)}{g_c} + A_4 dp = -\frac{4f\rho V^2 A_4 dr}{2g_c D_h} \qquad (B\text{-}7)$$

If pressure changes in the inlet and outlet heads are considered simultaneously, the momentum term $[d(wV)/g_c]$ in Equation (*B*-7) cancels out, as shown in Figure 2D. The remaining pressure change is that due to friction; thus

$$dh = -\frac{4fV^2 dr}{2g_c D_h} \qquad (B\text{-}8)$$

INLET HEAD: For the inlet head there is fluid withdrawal.

$$V = w_4/\rho A_4 \qquad (B\text{-}9)$$

$$D_h = A_4/\pi r \qquad (B\text{-}10)$$

$$w_4 = w_e - \Delta w \qquad (B\text{-}11)$$

$$w_T = w_e + w_d \qquad (B\text{-}12)$$

$$\Delta w = \Delta A_T \; w_T/A_T \qquad (B\text{-}13)$$

$$\Delta A_T = \int 2\pi r dr \qquad (B\text{-}14)$$

Combining Equations (*B*-9) through (*B*-14) with Equation (*B*-8) and integrating results in

$$(\Delta h_4)_4 = \frac{-\pi f}{\rho^2 g_c A_4^3}\left[\frac{w_T^2(r_g^2 - r_e^2)}{4} + \frac{\pi w_T^2(r_g^2 - r_e^2)^2}{2A_T} + \frac{\pi^2 w_T^2(r_g^2 - r_e^2)^3}{3A_T^2}\right] \qquad (B\text{-}15)$$

The friction factor f is determined from the Moody charts (*9*). The wall roughness must include projections from the tube-sheet surface, which in this case amounted to an average of about 1/16 in. The Moody friction factor equals $4f$.

OUTLET HEAD: For the outlet head there is fluid addition. By the same type of analysis as for the inlet head, the friction loss is found to equal that for the inlet head and is given by Equation (*B*-15).

PRESSURE DROP FOR COMBINED INLET AND OUTLET HEADS: Since there is no difference in kinetic energy between the inlet pipe and exit pipe, and the exchanger is assumed to be in a horizontal position, the pressure drop for the heads is equal to the sum of the friction losses.

Notation

A = cross-sectional area for flow, sq.ft.
A_t = one half the tube outside surface area, sq.ft.
A_p = cross-sectional area of pipe, sq.ft.
A_s = surface area of each path of the exchanger, measured from a point in the exchanger to the end at which the tube-side fluid enters. A_s varies from 0 to A_t
A_T = total area of tube sheet enveloping the tubes, sq.ft.
A_1 = free cross-sectional area for flow at point 1, sq.ft.
A_2 = channel cross-sectional area, that is, free area for section between a and b, sq.ft.
A_2' = free area for section between a and b and between a and c, sq.ft.
A_4 = cross-sectional area perpendicular to flow along section 4, sq.ft. Note that $A_4 \cong A_{bd} = A_{gh}$ because of constant-area design basis.
b = channel width, ft.
c = specific heat of tube-side fluid, B.t.u./(lb.)(° F.)
C = specific heat of shell-side fluid, B.t.u./(lb.)(° F.)
d = differential operator, dimensionless
D_h = hydraulic diameter of channel at point in question, ft.
f = Fanning friction factor, dimensionless
F = force, lb. force
g_c = conversion factor, 32.17 (lb.)(ft.)/(lb. force)(sec.^{2})
h = fluid head, ft.
$(K_1)_1$ = contraction loss coefficient, $\psi(A_1/A_p)$, dimensionless
$K_{2.1}$ = number of velocity heads for a 90° bend, dimensionless. This is a function of R'/D_h [See (*1a*).]
$(K_o)_2$ = contraction loss coefficient, $\psi(A_2/A_2')$, dimensionless. [See (*10a*).]
L = length, ft.
L_R = total length of channel, ft.
L_2 = length of channel, ft.
m = mass, lb.
p = pressure, lb. force/sq.ft.
r = radius, ft.
R = outer radius of channel, ft.
R' = radius of curvature of flow channel at point in question, ft.
R_2' = average radius of curvature, ft.
r_g = radius, ft., of the circle which encloses 50% of the total number of tubes
r_e = radius, ft., taken to the point where the area perpendicular to flow is established as follows. On Figure 1B line *ef* is located so as to be as long as line *bd* and to be more perpendicular to the flow
t = temperature of tube-side fluid, ° F.
t_x = tube-side fluid temperature in the path which has a flow equal to xw
t_{1-x} = tube-side fluid temperature in the path which has a flow equal to $(1 - x)w$
T = temperature of shell-side fluid, ° F.
U = over-all coefficient of heat transfer, B.t.u./(sec.)(sq.ft.)(° F.)
V = linear velocity, ft./sec.
V.H. = velocity head, lb. force/sq.ft.
V_1 = velocity in channel at point 1, ft./sec.
$V_{2.1}$ = average velocity in segment 1 of section 2, ft./sec.
V_2 = velocity based on A_2, ft./sec.
w = weight rate of flow of tube-side fluid, lb./sec.
w_e = total weight rate of flow through tubes outside from under deflector, lb./sec.
w_d = total weight rate of flow through tubes under deflector, lb./sec.
w_T = total weight rate of flow through heat exchanger, lb./sec.
w_4 = weight rate of flow radially outward in section 4, lb./sec.
W = weight rate of flow of shell-side fluid, lb./sec.
x = fraction of stream w flowing in one half of heat-exchanger tubes, dimensionless
z = height of heat-exchanger–head channel, ft.
$(\Delta h_i)_1$ = friction loss due to contraction
Δh_2 = friction loss for flow channel, ft.
θ = time, sec.
ρ = fluid density, lb./cu.ft.
ψ = a function

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PROFESSIONAL STANDARDS AND EMPLOYMENT CONDITIONS

Unlike the members of most learned professions, the engineer usually is an employee rather than a private practitioner. Surveys indicate that about eighty per cent of professional engineers are in the employee classification, and this situation sometimes creates special problems which are not inherent in the other professions. One such problem is how specifically to create and maintain an employment atmosphere consistent with high professional standards.

Certain conditions of employment have had a profound influence on engineers and, among other factors, have caused a number of professional employee groups to turn to collective bargaining. There is a need, therefore, for the engineering profession to state clearly the employment conditions that engineers expect as professional men. Employers should align their policies with respect to the engagement of professional engineering personnel to meet these expectations. Mutual understanding between employers of engineers and the engineering profession is essential to the establishment of an environment which will encourage the individual engineer to achieve full professional stature.

A Statement from EJC President Chilton . . .

This report represents the labors of many thoughtful people who have considered and discussed the problems of engineers as employees. A wide diversity of views was to be expected on problems having as many ramifications as these have. The report was finally adopted only after review by the EJC Executive Committee and a Special Task Committee following months of arduous work by EJC's Committee on Employment Conditions.

It is, therefore, not the work or view of any one individual, and perhaps everyone will find some part of it with which he does not fully agree. It does, nevertheless, represent, I believe, a significant appraisal of employment factors which deserve attention. The EJC Board of Directors endorses the recommendations contained in this report and strongly urges the constituent societies to examine this entire study carefully.

Each of us, as professional engineers, and all others directly or indirectly associated with the profession, must strive diligently to establish a clear understanding of employment conditions necessary to meet professional employee expectations. An employment environment which encourages full professional and technical development of employed engineers is essential to the advancement of the profession and the realization of their fullest contribution to the economy.

Thomas H. Chilton, President, EJC

The Report Recommends that:

- **MANAGEMENT:** utilize the services of engineers more effectively and thereby afford them opportunity for advancement and economic improvement

  recognize its responsibility to make engineers feel that they are a part of management

  survey areas of communication, recognition, and salaries and, where found wanting, correct to conform with standards of professional practice

- **ENGINEERS:** take inventory of their services and actions to make sure that they have a professional attitude toward their work

- **ENGINEERING SOCIETIES:** establish and employ appropriate means to maintain high standards of ethical conduct for professional achievement

  encourage the professional development of their members and promote proper recognition of the profession

- **ENGINEERING EDUCATORS:** emphasize the characteristics of the profession

The expansion of engineering from its beginning in military and civil engineering a century ago to a multiplicity of disciplines today has created a host of problems. Of major concern to the engineer is his relationship as a professional man with his employer. This relationship is influenced largely by employment conditions including salaries, training programs, security policies, levels of responsibility, job classifications, and identification with management.

Because the needs, responsibilities, and contributions of professional employees have not been recognized adequately in some instances there has been a movement toward the unionization of engineering personnel. This has had an adverse effect on the professional concepts of many engineers, for a professional man must rely first on his own personal competence and integrity for recognition. In addition, confidential relationships which should exist between employers and professional engineers have been jeopardized.

The fact that there has been a trend toward collective bargaining by engineers, in spite of widespread reluctance to participate in such action, demonstrates the existence of unsatisfactory conditions. The engineering profession and management have a great stake in the solution of the problem and the latter must accept its share of the responsibility for alleviating unfavorable employment conditions.

Faced with these conditions, some engineers have resorted to unionization in the belief that corrective action could be effected only by pressures on management through collective bargaining. Even though they may have realized that professionalism requires freedom of action, these engineers appear to have been willing to submerge this principle in their attempt to get more pay and better work conditions through union activity.

Historical Background

The accelerated development of mass-production techniques in this century stimulated a rapid rise in labor union activities. Labor and management faced common problems of increasing complexity. In 1935 the United States Congress enacted the National Labor Relations Act, better known as the Wagner Act, which guaranteed to employees the right to organize and to bargain collectively and protected labor unions against specified unfair labor practices on the part of management. At that time there was little realization on the part of the professions of the potential impact of the Wagner Act on professional employees. However, the established labor unions soon took advantage of the situation and it was not long before many professional employees found themselves included, against their individual desires, in heterogeneous bargaining groups.

Legally, it was possible to form bargaining groups composed solely of professional employees. Practically, it was difficult to do so. Wherever a heterogeneous bargaining unit existed, it was next to impossible for professional employees to segregate themselves since the Wagner Act made no distinction between them and nonprofessional workers.

Some engineering societies, particularly the American Society of Civil Engineers, undertook to chart a course of action designed to assist professional employees against inclusion in heterogenous groups. At first, the effort met with but minor success. Later, Engineers Joint Council determined to present its views to Congress with the hope that the Wagner Act might be amended to provide recognition of the status of professional employees and to enable them to act effectively in their own behalf. Pertinent clauses were included in the Labor Management Act enacted by the Congress in 1947—better known as the Taft-Hartley Act [Section 9(b)].

Under the Taft-Hartley Act a group of professional employees in any place of employment may decide by majority vote of their own numbers whether they want to form a unit of their own for collective bargaining purposes, to join with some other bargaining group, or to refrain from collective bargaining entirely.

It was hoped that the amended act would provide a satisfactory solution to the inclusion of engineers in heterogeneous unions. Professional employees could disassociate themselves from heterogeneous groups. It was not expected that employees of professional status ever would desire anything like a nation-wide bargaining union. It was hoped that labor unions would respect the statutory rights of professional employees. Those hopes today lack much of full realization.

A number of bargaining groups of professional employees have come into existence. Some appear to have functioned constructively; the same hardly can be said of others. Already there is a nation-wide union, self-designated as an engineering union, which aspires to power. Although some professional employees have been able to disassociate themselves from heterogeneous groups, craft unions, particularly in the construction industry, are forcing more and more engineers into their ranks by bringing economic pressure upon employees, thus avoiding the election machinery of the Taft-Hartley Act. Clearly, many members of the engineering profession and employers of engineers are not doing enough to ensure enforcement of the letter and spirit of the law.

The recent merging of the American Federation of Labor (AFL) and the Congress of Industrial Organizations (CIO) brings into being a large and powerful union organization among whose objectives are increased efforts toward unionization of office employees and technical personnel. That effort will have direct impact on professional engineers.

Who Wants Collective Bargaining?

To obtain reliable statistics regarding the current status and thinking of a cross-section of the engineering profession, four constituent members of EJC, namely ASCE, ASME, AIEE, and SNAME, polled 117,917 of their members on specific questions concerning collective bargaining. Of those polled 66,938, or 57%, responded.

Returns showed that 48,082, or 72%, of the 66,938 respondents opposed collective bargaining for professional engineers, and that 44,168, or 66%, felt that collective bargaining is incompatible with professional status.

Further, the 66,938 responses showed that less than 4% were actually members of established collective bargaining groups; 27% reported not being opposed to collective bargaining; 20% reported that they believed collective bargaining would be advantageous to them; and finally, less than 1% of the membership of three member societies (the fourth did not ask the question), would prefer to be represented by a craft labor union.

These results present a challenge to the engineering profession and to engineering management. The thinking of the remaining 43% of the 117,917 members polled, who did not respond to the questionnaire, is still unknown, but, assuming that the sample was representative, there would then be 30,300 members who are not opposed to collective bargaining for professional engineers.

These results emphasize the situation confronting the profession in spite of the protective clauses in the Taft-Hartley Act.

The Problem and Suggested Solutions

A summary of the above might lead to two basic reasons for the present situation: engineers have not always realized and understood the professional characteristics of their roles; and management has not always realized and accepted its obligations to engineers.

If these are the causes, the problem then may be stated as how to get the engineer to appreciate the professional characteristics of his position and how to get management to realize and accept its obligations to its engineers.

Immediately certain solutions present themselves, and these may be listed under five main headings:

1. Point out to the engineer and re-emphasize to him that engineering is a profession and that he therefore has certain definite responsibilities.
2. Point out to management, through all feasible ways, that it has responsibilities to the engineering profession.
3. Point out to professional societies the part which they should play in the advancement of their profession.
4. Point out to engineering educators their responsibilities for developing professional concepts in their students.
5. Point out to society the contribution of the engineer to its general welfare.

The purpose of the rest of this report will be to bring to the attention of all concerned their respective responsibilities and to stimulate a realization on the part of the public that engineering is a profession with high ideals and one that has made preeminent contributions to our modern civilization and high standard of living.

Engineering—A Profession

Engineering is the art and science by which the properties of matter and energy are made useful to man in structures, machines, and products. Accomplishment of these ends requires not only scientific training, but also creative imagination, judgment, and an appreciation of the economics involved. The work of the engineer is predominantly intellectual and varied. The dictionary defines engineering as a mental activity rather than a manual skill. The engineer must exercise discretion and judgment, he must wish to serve, and his relationship with management must be one of confidence; in fact he is part of management. The engineer is charged with the protection of the public health and the public safety. The builder of a bridge, an airplane, a water supply, a dynamo, a kitchen range, an automobile, or a chemical plant must be concerned with its safe operation. Responsibility rests upon his shoulders; if he does not accept that responsibility, he is not professional.

Professions require knowledge and skills on a high plane and all require that the practitioner work in a relation of confidence. In the ministry, medicine, and law this relationship is usually on an intimate personal basis, but in engineering it usually is more general and, indeed, involves obligation to the public at large as well as to the employer or client. The engineer's code of ethics requires that "he will have due regard for the safety of life and health

of the public and employees who may be affected by the work for which he is responsible" and that "he will act in professional matters for each client or employer as a faithful agent or trustee."

Since clients and employers usually do not have the technical knowledge necessary to judge technical work, the engineer is bound to place their protection above his personal convenience or his immediate personal gain. A fundamental principle of professional responsibility is trusteeship. This is also a fundamental principle of management. To the employed engineer this means that the professional attitude involves a "management-oriented" point of view.

Engineering operations today are varied and extensive. Men at all levels of training and competence are required to carry out vast engineering enterprises. The work of the draftsman, the layout man, the toolmaker, the plant operator is indispensable, but does not require the imagination, the educational background, nor the judgment of the engineer who conceives and executes the broader aspects of the projects.

The work of a truly professional engineer is so far from a routine, established pattern that only he can provide the initiative, the discretion, and judgment to achieve the successful accomplishment of his particular tasks. Because he alone knows with what comprehension, ability, and likelihood of success he approaches his assignment, the professional must accept individual responsibility or else advise his client or employer that other help is needed.

Prestige, however, is something that must be won. It cannot be bought or automatically accorded through affiliation with an organization. It is something that one can *command* but never *demand*. In the final analysis, an engineer achieves professional standing only to the extent that he accepts his responsibility to himself, to his client or employer, and to society.

Attainment of a degree in engineering from an institution of recognized standing implies that the graduate has mastered a certain curriculum and that he has the ability to understand, to assimilate, and to apply the knowledge that qualifies him to become a member of the engineering profession.

Although social consciousness is not necessarily a corollary to superior mental competence, most people who are endowed with such competence do have a sense of responsibility to the social order of which they are a part. They have learned to look on life as an opportunity to contribute to the civilization that fostered them and thus to better the lot of those who follow. To the engineer who feels that life provides opportunity for constructive contribution to society, collective bargaining with its attendant potentiality for creating conflicting obligations is not acceptable.

Employee's Responsibility

The engineering employee is bound by the same ethical and moral principles that apply to a member of any other learned profession. The responsibilities of an engineering employee are many. He is obliged to perform the professional assignments entrusted to him to the best of his knowledge and ability. He should give needed professional council in his special field and render loyal service. He should respect the economic problems of his employer. He should be thorough, expeditious, original, and accurate in the execution of his duties and assignments. He should have a rational attitude toward his work and fulfill each task with a minimum of supervision. At all times he should strive to improve the quality and increase the quantity of his output.

Education is important to the engineer and he should foster its continuance for those who are subordinate to him. He should strive to recognize and to utilize the diverse capacities of all fellow employees. He should strive for good planning and clear, concise reports. He should be friendly and maintain good appearance. He should develop the ability to be a good listener as well as the ability to express his thoughts effectively.

It is axiomatic that just as management has responsibility to employees, so do employees have responsibilities to management. The engineer employee should realize that he is not just another hired hand. He should know that to achieve full professional stature he must develop himself to rise above the technician or engineering-assistant. He must have genuine desire to expand his capacity, to extend his knowledge, and to improve his proficiency.

Any employee who is unwilling to assume responsibilities beyond those accompanying his present job has little right to be critical about lack of advancement. If he feels that he is not getting earned recognition, it well may be that critical self-appraisal is in order. One cannot just wish himself up the ladder or depend on someone else to push or pull him along the way to success. The fact that a man has acquired a bachelor's degree in engineering does not, of itself, entitle him to any lasting professional recognition. It remains for each individual to prove by his own ability, integrity, and conscientious application to duty that he deserves recognition.

Management's Responsibilities

Surveys show that more than forty per cent of management were trained as

CAUSES FOSTERING COLLECTIVE BARGAINING AMONG ENGINEERS

PROFESSIONAL TREATMENT

A feeling among engineers that they were not identified with management, whether they were employees in industry, private engineering firms, or public service.

Inadequate channels of communication between top management and nonsupervisory engineers.

Inadequate recognition of the engineer as a professional employee.

Assignment of engineers to subprofessional work.

Undue retention of engineers in specialized and narrowly compartmentalized assignments.

Lack of appropriate means for resolving individual problems.

PERSONAL TREATMENT

Inadequate recognition and treatment of the engineer as an individual.

Lack of broad position classifications and appropriate titles by which the engineer could measure his progress.

Inadequate or nonexistent plans for training and job rotation.

Inadequate understanding of promotional policies and belief that progress and promotions were not commensurate with ability and performance.

Feeling of insecurity of employment.

Management's human relations knowledge and skills have not kept pace with the expanded utilization of engineers.

FINANCIAL TREATMENT

Engineering salaries not commensurate with fundamental contribution.

Too small a differential between the pay of engineers and members of the skilled trades.

Salaries of experienced engineers not sufficiently increased, in comparison with present starting salaries.

Wide variation in salaries paid to engineers doing comparable work in different organizations.

Dissatisfaction with merit review systems and inadequate understanding of salary administration.

engineers. It seems illogical, therefore, that often there is inadequate communication between management and engineers with consequent lack of understanding on the part of management of the reasons for dissatisfaction among professional employees.

Management must recognize the inherent professional character of engineering work. It should be a policy of management to use its professional employees to the maximum of their capabilities. Except during the training period the engineer should not be assigned to tasks which do not require his technical training and he should be accorded individual and professional status commensurate with the quality of his contribution.

There must be opportunity for a continuation of education. It is important that professional employees be given opportunities to participate in activities of scientific and technical societies. It is important that they receive credit for their contributions to the advancement of technical knowledge or the profession as a whole.

There must be adequate communication between management and the professional employee. There should be organized orientation and training programs for new employees. Engineers need to understand the basic policies of their employer. They need to know their responsibilities and their opportunities for advancement. Adequate management-employee communications require a day-to-day relationship supplemented by periodic performance reviews, and other appropriate techniques.

Salaries must be established which will recognize the contribution of the professional employees as related to that of other groups. Salary differentials between various levels of technical experience have been substantially narrowed during recent years. Engineers who, after a period of satisfactory employment, find their salaries are only slightly higher than those of the recent graduate and possibly lower than those of a skilled craftsman, are not working in a favorable atmosphere.

Management must minimize the fear of job insecurity by adopting feasible means for stabilizing the employment of professional personnel and suitable termination policies. Since many engineers become managers, there is a need to insure that they are employed and developed in an atmosphere which will fit them for their future responsibilities. Executive talents must be developed by experience and training in those phases which lead to managerial responsibilities.

WHAT IS THE PROFESSIONAL ATTITUDE?

A social consciousness, a desire to contribute to rather than simply to benefit from civilization; a resolve to place the public welfare above other considerations.

The acquisition of special skills on a high intellectual plane, generally evaluated by means of self-imposed standards of excellence.

A sense of trusteeship—personal responsibility to protect the client's or employer's interest.

Individual initiative and acceptance of individual responsibility, both of the highest order.

A right to expect and to receive adequate financial recognition.

Engineering Societies' Responsibilities

The engineering societies must take the lead in the advancement of the profession. Among the basic responsibilities of the engineering societies are the establishment of standards of ethical conduct, rigid requirements for admission to membership, accreditation of educational institutions which grant engineering degrees, and awards and prizes in recognition of worthy contributions to the advancement of the profession.

The national engineering societies have an additional responsibility to foster a healthy professional climate for employed engineers. Their governing boards and their individual members should unite in exerting their best efforts toward solving the problem. These responsibilities are so challenging and so vital to the current problem that they must be considered as obligations.

Current efforts of national committees to encourage professional development of engineering society members and to promote recognition by the public of the professional character of the engineers' work should be expanded. An objective evaluation of the problem should be continued, followed by specific recommendations for the good of the profession. Engineering societies should adopt official statements for membership information with respect to collective bargaining to the extent permitted by their charters and constitutions. They should acquaint their memberships with those provisions of the Taft-Hartley Act which have a special significance to professional engineers. Constructive programs for encouraging professional consciousness on the part of the engineers both before and after graduation should be sponsored. Therefore, the engineering societies and Engineers Joint Council should inform management as to the standards that will contribute to full professional achievement.

The engineering societies should provide guidance and assistance to educational institutions confronted with any problem which is detrimental to the achievement of full professional training of students.

Engineering Education's Responsibilities

Engineering colleges have a primary responsibility for developing professional concepts in engineering students. Professional concepts should be developed through their application to the solution of engineering problems in the technical courses, lectures, association with students, and by good example.

Opportunities for engineering educators to become better acquainted with the total environment in which engineers work should be expanded through temporary employment in nonacademic fields and the utilization of employers with "professional vision" in the classrooms and student seminars. Such activities enable students to appraise their status more realistically upon graduation.

Conclusion

There are obligations and responsibilities resting on both employer and employee. Each, of course, has responsibility to advance his own welfare. Beyond that, and yet a part of it, each has responsibility to the other and to society. Grave responsibilities for inculcating and developing professional consciousness in young members of the profession rest upon the educational institutions and professional societies. Various phases of such responsibilities have been stressed in the several sections of this report.

Without a sound technical foundation no man can become a competent engineer. But more than technical competence is demanded of one who expects to be recognized as a professional person. One must understand and observe appropriate ethical standards and it is important to cultivate proper understanding of such standards.

(*Continued on page* 56)

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PROFESSIONAL STANDARDS

(Continued from page 54)

The ECPD program "The First Five Years of Professional Development" is an excellent step in the right direction. Here is opportunity for the engineering societies, the colleges, industrial management, and civic institutions to work together to aid young graduates in continuing their education and in adjusting themselves to conditions to be met in the practice of their profession.

The present report has been prepared with full realization that the subject refers chiefly to one phase of professional life. An attempt has been made to identify factors that have significant bearing on the specific problem under consideration. Concerted efforts by all concerned with advancement of the profession are required if satisfactory solution is to be found. It is believed that if the recommendations submitted are followed by those to whom they are directed, substantial improvement in the standing of the profession will result.

The second annual Trade Fair of the Atomic Industry has been moved from the Morrison Hotel, Chicago, to the Navy Pier in the same city. Reason: Heavy demand for space required a much larger location. Running September 24-28, the Fair will be concurrent with a major Atomic Industrial Forum meeting on "Management and Technology for the Atomic Industry," September 25, 26, and 27. The Forum is sponsor of the Trade Fair. For the Forum meeting, the Morrison Hotel is still the headquarters. □

A new course, "Nuclear Engineering Topics," brings to the campus of Purdue University's Chemical and Metallurgical Engineering School an outstanding nuclear engineer each week. So far, Stuart McLain has discussed fuel element removal, and J. R. Dietrich has devoted two lectures to boiling water reactors. □

We lose nearly as much water as we use. Reason: Evaporation. This was the conclusion reached by scientists at the Southwest Research Institute, and as a result of it they are now conducting investigations into a new method of preventing evaporation developed by an Australian scientist, W. W. Mansfield. The method, using a thin (1 ten millionth of an inch) chemical film, reportedly reduces evaporation 45% and is harmless to fish, animals and plants.

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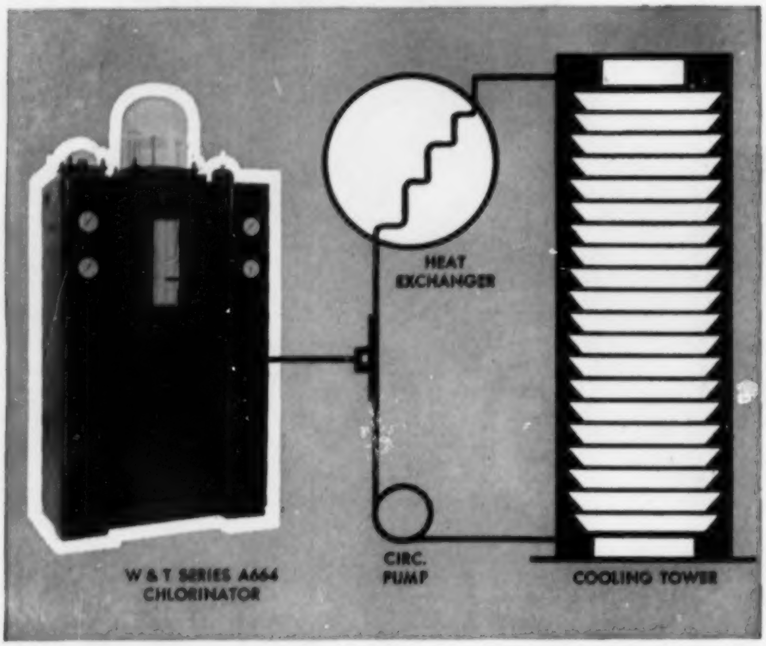

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CHEMICAL ENGINEERING DIVISION OF ASEE TO HOLD ANNUAL MEETING

Place of this major meeting in the field of chemical engineering education will be Ames, Iowa. Date: June 25-26.

A full program is scheduled for this important meeting of chemical engineers concerned with the future of the field. J. O. Hougen, Rensselaer Polytech, is program chmn., and E. Lightfoot will preside over the Monday, June 25, program, which will consist of: D. L. Katz on "A Professional Program for Advanced Study in Engineering"; J. C. Garver on "The Bioengineering Program at Illinois"; R. Bird discussing "Advances in Diffusional Processes"; and W. E. Ranz on "Atomization."

The Monday dinner meeting will hear A. W. Davison, Owens-Corning, discuss the "Technical Manpower Situation."

Tuesday's sessions will be presided over by M. Smutz, and will consist of: L. V. Parsegian discussing "The Role of Nuclear Courses in Engineering Curricula"; R. Taecker presenting "The Nuclear Engineering Program at Argonne National Laboratories"; J. Roberts on "Digital Computing Devices"; and W. Stoker on "Analog Computers."

A training school for fabricators, distributors, piping contractors and industry in the application, fabrication, welding and forming of unplasticized polyvinyl chloride materials, has been established at Lawrence, Mass., by H. N. Hartwell & Son, Boston, and Bolta Products, a division of General Tire & Rubber. Called the Plastics Fabricating Institute, it will have special sessions on the proper methods and techniques in the installation of PVC pipe. □

Unit Processes in the Fatty Oil, Soap, and Detergent Industry, is the theme of the 8th Annual Short Course sponsored by the American Oil Chemists' Society at Purdue July 16-20. A roster of outstanding experts in the field will present papers. Advance registration is required. Contact the Society's office, 35 E. Wacker Drive, Chicago 1. □

The Summer Laboratory Course in Techniques and Applications of the Electron Microscope, at Cornell, will be given this summer from June 11 to 23, under the direction of B. M. Siegel. C. E. Hall of MIT, and R. C. Williams of the Univ. of Cal., will be guest lecturers. □

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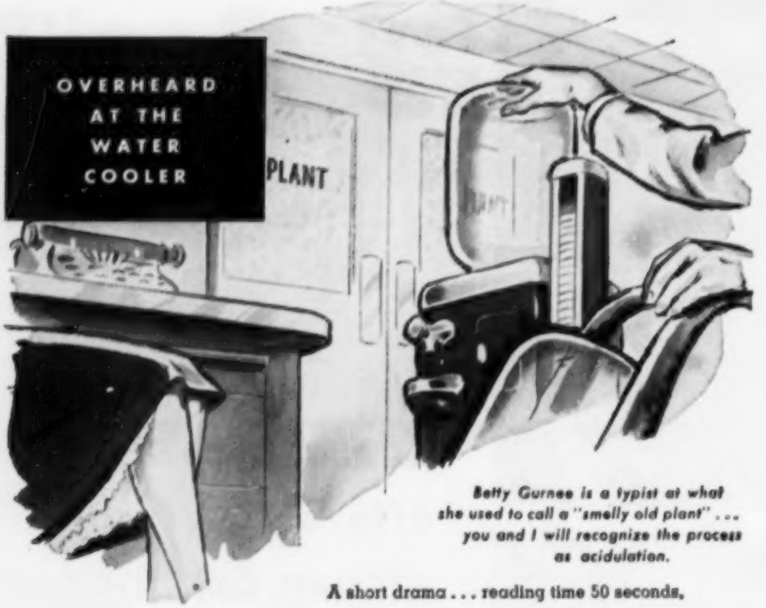

Betty Gurnee is a typist at what she used to call a "smelly old plant" . . . you and I will recognize the process as acidulation.

A short drama . . . reading time 50 seconds.

He: "Got a bunch of camels around here now? I used to fill this bottle twice a week."

Betty: "Nobody, I repeat, *nobody* used to miss that water cooler on their way out of the plant. But, since we got the new doo-dad out there . . . why, it's *almost* like a bonus."

He: ***(Exit, with bottle, muttering)***

That "doo-dad" was a Simpson Mix-Muller. Betty's Boss had two reasons for buying it and only one had to do with personnel relations. He found that the Mix-Muller saved him the cost of ventilating one whole section of his plant. With it, he was able to control dust and noxious fumes from acidulation *at the mixing source* . . . because the Simpson Mix-Muller can be *readily* adapted for air exhaust or completely enclosed.

Control of dust and noxious or toxic fumes from dusty and dangerous processes is only one of the many adaptabilities of the Simpson Mix-Muller. It can be as easily adapted for heating, cooling or chemical reaction while mixing because it's designed and built to act as an integral *part of a process*. Some of these processes are described in our new "Handbook on Mulling". Write for your copy today and remember . . . mixing and the integration of mixing facilities is our *business* at National, it has been for over 40 years.

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COST ESTIMATORS TO FORM NATIONAL ORGANIZATION

Organizational meeting of proposed new national organization is scheduled for June 1-2 at the U. of New Hampshire, Durham, N. H.

Tentatively named The National Association of Cost Estimators and Cost Engineers, the proposed new organization will come into being at the New Hampshire meeting.

Under the impetus of the work of Irvin Lavine, Industrial Research Service, Inc., and N. G. Bach of Monsanto, among many other active cost engineers behind the proposed organization, the New Hampshire meeting is scheduled to adopt a constitution and by-laws, sign the constitution with all charter members present, elect officers, install officers, select the time and place of the next meeting.

The best articles from European technical and industrial journals, translated and digested, are now available monthly to American industry through the Office of Technical Services, U. S. Dept. of Commerce. The means: distribution of the monthly publication "Technical Digests" published by the Organization for European Economic Cooperation. ☐

A technical writing workshop to provide practical instruction and supervised practice in the efficient preparation of effective technical reports will be held at the Pennsylvania State University, September 16-28.

The workshop will be limited to 40 practicing scientists and engineers, will have morning lectures and afternoon workshop periods. ☐

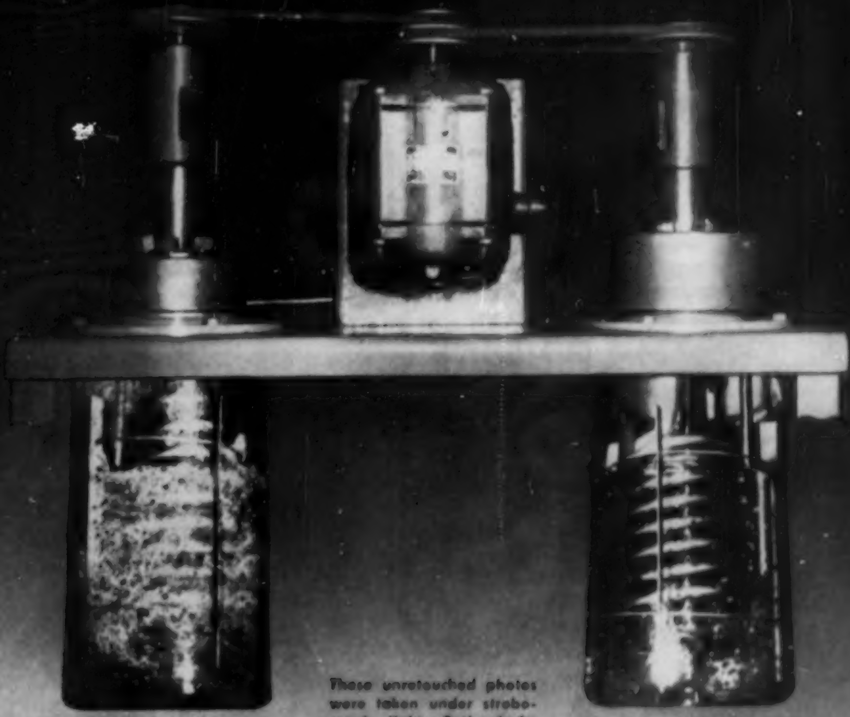
A $2 million gift toward the completion of the engineering and science center of New York University's Heights campus has just been made by Frank Jay Gould, noted American financier. ☐

A three-year contract for research into titanium has been awarded to the metallurgy division of the chemical engineering department of the Univ. of Tenn. Contract comes from the U. S. Office of Naval Research. ☐

The most comprehensive instrument-automation event in the world, ISA's 11th Annual Instrument-Automation Conference and Exhibit, is scheduled for New York City September 17-21.

NEW AUTOCLAVE "DISPERSIMAX" . . .

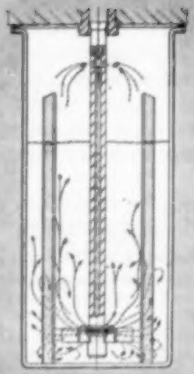
The Answer to Maximum Gas Dispersion



"Dispersimax" Agitation

These unretouched photos were taken under stroboscopic light. Both shafts rotating at 600 r. p. m.

Ordinary Agitation



The path of the dotted arrows indicates Flow Pattern.

Autoclave Engineers have been instrumental in the development of the "Dispersimax." The impeller of this device pumps gases continually through a liquid kept in constant agitation in the presence of a suspended catalyst. This greatly increases the interfacial contact of solids, liquids and gases. Extensive tests at the University of Pennsylvania have shown that this device will decrease reaction time many fold and in a great many cases is expected to result in reactions taking place at lower pressures, which would mean lower costs for plant size equipment. The drawing at the left shows how the "Dispersimax" works. The hollow rotating shaft is provided with inlet ports above the liquid level and outlet ports at the impeller. Rotating impeller blades at the bottom of the shaft create a suction which circulates the gas continuously down through the shaft and out through the liquid with its suspended catalyst.

Here is another example of Autoclave Engineers constant search to produce better tools for research. Write for Bulletin No. 1254.

SPECIALISTS IN

LABORATORY AND PILOT PLANT HIGH PRESSURE EQUIPMENT

AUTOCLAVE ENGINEERS

2930 WEST 22ND STREET • ERIE, PENNSYLVANIA

For Optimum Efficiency at Minimum Cost, Heat Transfer Equipment Needs Kellogg's

BUILT-IN ENGINEER

WHEN a process plant's efficiency, and even its economic success, depends on the performance of heat exchangers, this vital equipment becomes more than a "packaged" item or even a matter of following specifications. Optimum performance, at minimum cost to the customer, demands all of the extra know-how, know-when, and know-where that the fabricator can put into the job. It requires, for example, a thorough knowledge of heat transfer, stress analysis, metal fatigue, corrosion control, metallurgy, and welding techniques, plus the inherent ability to apply this knowledge to the specific problem at hand.

At M. W. Kellogg, the instinctive application of this kind of knowledge—which goes into the design and fabrication of every Kellogg heat exchanger or other processing unit, is what we call the "built-in engineer". This important extra, together with Kellogg's other facilities guarantees performance, minimizes maintenance, and often reduces initial costs. In one recent instance, a saving of $5,000 for a customer resulted from a slight change in design suggested by Kellogg's staff.

We welcome the opportunity to demonstrate, in cooperation with your own design engineers or alone, what Kellogg's "built-in engineer" can contribute to *your* new process equipment.

Fabricated Products Division

THE M. W. KELLOGG COMPANY, 711 THIRD AVENUE, NEW YORK 17, N. Y.

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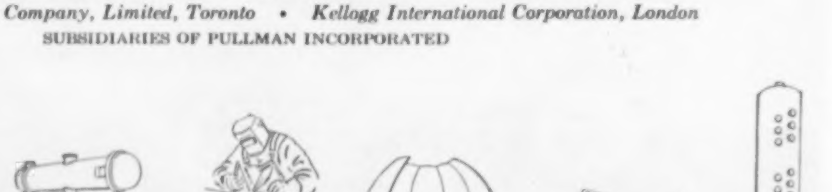


MAJOR PROCESS OPERATOR ENTERS ALUMINUM FIELD

Olin Mathieson will enter aluminum industry with giant facilities. Initial investment: $120 million. New plant marks potential chemical boom of Ohio Valley area.

With what is believed to be the world's first fully integrated aluminum plant, Olin Mathieson is entering the aluminum industry, according to the announcement of President T. J. Nichols.

Sidelight: the new operation will mark the first time in aluminum history that power will be provided from coal mined directly on the site.

Located in the Ohio River Valley, the alumina plant, reduction plant, and rolling mill will be on the river near Clarington, O.; the power plant, engineered and built by American Gas and Electric, will be slightly upstream at Cresap Bottom, W.Va. The power plant will be built on a major new coal mine constructed, owned and operated by Pittsburgh Consolidation Coal Co.

The alumina plant will have a capacity of 230,000 tons/year, the aluminum plant a capacity of 60,000 tons/year. At first only some 115,000 tons of alumina will be required for the aluminum plant, the surplus alumina will be available to the market. Olin expects to use most of the aluminum production itself, but will remain both a buyer and seller of aluminum in order to keep the fabricating facilities in balanced supply.

Investment breaks down into about $90 million for the aluminum plant, $30 million for the power facilities. Money will come from the company's own resources and two long-term loans from Prudential Insurance Co.

The power plant will consist of two units, 225,000 kilowatts each. Both units will be operated by the Ohio Power Co. and integrated into the American Gas and Electric Co. system. The plant is being designed for up to 1,350,000 kilowatt capacity.

The difficulties of inter-state location, and local economic and physical problems, were worked out with the full cooperation of the Governors of both W. Va. and Ohio and the local authorities.

Power and alumina, left, reduction plant, center, and rolling mill, upper right, of Olin's planned new major primary aluminum facility.

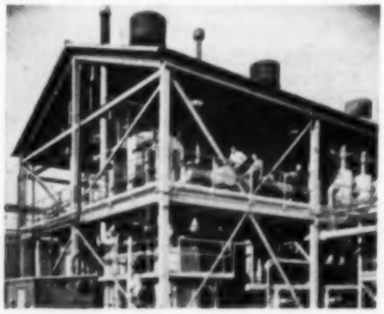
All facilities are planned for expansion in the future, and given the excellence of the location and the available power, both the companies involved and the local authorities expect the establishing of many "satellite" industries and other installations not connected with aluminum.

The plants are being constructed under certificates of necessity from the Government, issued in order to help increase the supply of primary aluminum.

Engineering studies are underway for a new tall oil fractionating unit at the Springhill, La., plant of Arizona Chemical Co., a jointly owned company of American Cyanamid and International Paper. □

Production of high quality zirconium silicate glaze opacifiers has been increased 35% by the addition of new facilities at Metal & Thermit Corp.'s plant. □

Tetrahydrofurfuryl alcohol is now being produced by the Chemicals Department of The Quaker Oats Co., by a new low pressure catalytic hydrogenation process developed in the company's research laboratories. Located in Memphis, Tenn., hydrogen is secured from a nearby plant. The new process will mean an immediate price cut, the new production will probably mean a still further reduction.



Hooker Chemicals' new $11 million chlorine-caustic plant at North Vancouver, B. C., will go into operation early in 1957 utilizing a new type electrolytic cell which permits operation at 30,000 amperes rather than 27,000, thus raising output per cell with no increase in floor space.

An Advanced Electronic Data Laboratory has been established as a new facility of Consolidated Electrodynamics Corp. to undertake development of advanced equipment in the magnetic-tape data-processing field under contract to governmental and private agencies.

A new facility for the manufacture of technical parathion is under construction at American Potash & Chemical's Eston Chemicals plant at Los Angeles.

A new Canadian plant for the production of its line of building maintenance and construction materials was opened recently by L. Sonneborn Sons, Inc., leading petroleum refiners, manufacturing chemists and producers of building and maintenance products. □

Mobay Chemical's new urethanes plant at New Martinsville, W. Va., completed only two months ago, will be tripled in size as soon as engineering and construction can be completed. □

Digesters fabricated with Iconel-clad steel appear to be the answer to the alarming increase in the corrosion rate for pulp digesters in the paper industry over the last 15 years. Although the definite reasons for this increase in the corrosion rate have not been determined as yet, variations in cooking liquor composition due to changes in chemical recovery operations, or simply increased production per vessel, may be the cause. Whatever the cause, Iconel-cladding seems to have gone a long way toward solving the problem. □

TURN FOR MORE NEWS ON

INDUSTRY ....page 64 et seq.
RESEARCH ....page 112
NUCLEAR ....page 114
OVERSEAS ....page 116

NEW LOW-COST PROCESS TO PROVIDE LONG-SOUGHT RAW MATERIALS FOR NEW CHEMICAL DEVELOPMENT

Peracetic acid, literally "frozen" out of traditional acetaldehyde-acetic acid production stream by Carbide and Carbon Chemicals, may be source of new chemical industry based on the higher epoxides.

Sizeable pilot plant now in operation, full commercial plant in two years. Carbide already offers samples of key epoxy derivatives for commercial development.

The wide commercial chemical possibilities of the higher epoxides (those above ethylene and propylene) have long been recognized, and have engaged the efforts of such companies as Becco Chemical, General Mills, Rohm and Haas, Du Pont, Carbide, and the Eastern Regional Research Laboratory of the Dept. of Agriculture. Work has centered about the use of peracetic acid as an epoxidizing agent, problem has been to produce the peracetic cheaply, in volume, and in physical condition to be most useful. Much work has been done on the use of H_2O_2 to oxidize acetic acid to the needed peracetic, but this process seems limited in application at present.

Now Carbide has come up with a process which seems to fit the requirements, is cheap, high-volume, and produces a grade of peracetic that will epoxidize just about any olefin. Carbide's research team under Benjamin Phillips, assistant director of research, took advantage of two basic facts: peracetic is very nearly an ideal epoxidizing agent under proper conditions, and in the commercial production of acetic acid from acetaldehyde the short-lived intermediate "acetaldehyde monoperacetate" is formed. Normally, this intermediate decomposes to acetic acid and acetic anhydride. But Carbide's engineers found a way to "freeze" the reaction by the relatively simple technique of maintaining the temperature of the reaction mixture below 15° C.

The Process

In essence the process is simple. Acetaldehyde is air-oxidized as if for the production of acetic acid. Instead of allowing the reaction to go to completion, the temperature is lowered to the point where the products are peracetic acid and acetaldehyde. These are then separated, giving peracetic in a non-ionic solution with an inert solvent. The peracetic is then used to epoxidize almost any unsaturated olefin. The result of the epoxidation is the epoxide and—acetic acid! The acetic produced this way is on the basis of one mol acetic for each mol of original acetaldehyde.

The importance of this reaction, commercially and from the engineering point of view, lies in the following three points:

1) Carbide, which normally produces acetic from acetaldehyde, utilizes an existent process stream to produce a basic raw material from which a whole group of commercially important new chemical derivatives can be made, and still ends with the original product—acetic acid—in very nearly the same quantity it would have had without the intermediate use of the stream. In short, Carbide simply "diverts" an existing process stream, uses it, and then gives it back.

Carbide officials discuss market potential of resins based on peracetic acid. L. to r., J. A. Field, vice-president; Dr. Benjamin Phillips, asst. director of research; R. W. Eddy, asst. mgr. fine chemicals; and W. A. Woodcock, mgr. fine chemicals.

Which all results in practically no raw material cost.

2) The "diversion" represents an interesting commercial-scale "freezing" of a fast chemical reaction.

3) The high purity and physical state of the peracetic acid produced makes it commercially much more broadly useful as an epoxidizing agent—which is the real engineering crux of the matter.

Epoxides

While peracetic acid has definite commercial applications of its own, such as a bleach and a germicide, the major engineering and commercial potential is its use as an epoxidizing agent.

Any one, or all, of the higher epoxides could open commercial fields as important as that of the epoxide, ethylene oxide. They can find important use in the manufacture of plasticizers, resins, coatings, surfactants, pharmaceuticals, and odorants, and many other large volume chemical derivatives for current or undiscovered uses.

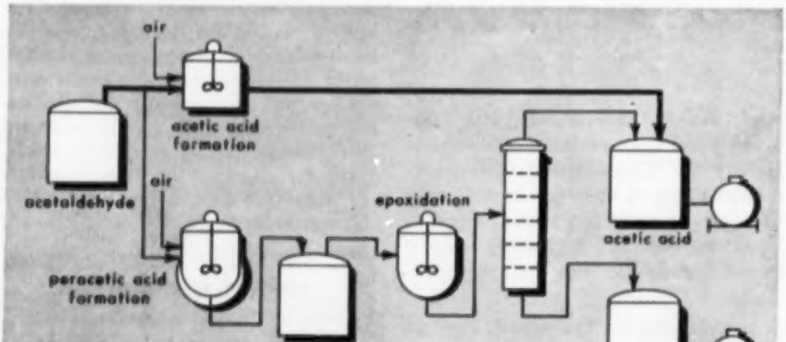
Already, Carbide is offering commercial samples of 8 major epoxidation derivatives, has made more than 375 in its development work, will custom-make any epoxide that is feasible. The 8 now available by circling the card on page 67 are:

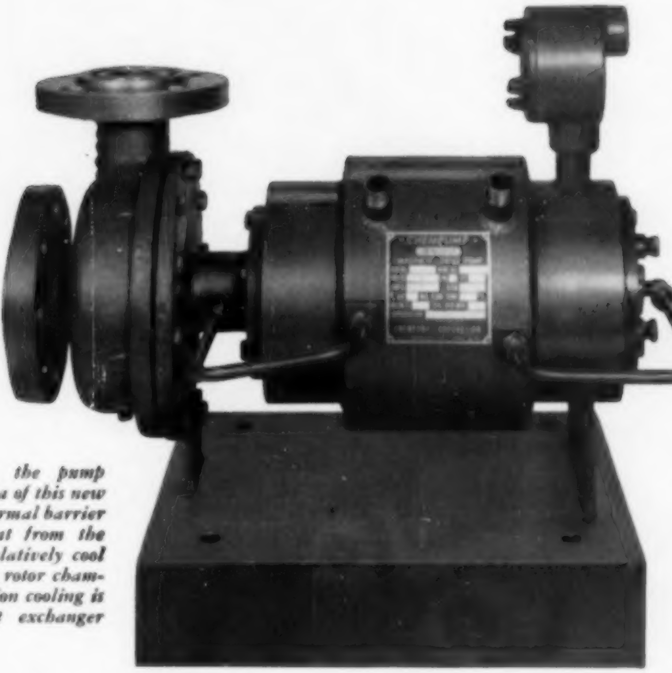
1,4-Dichloro-2,3-epoxybutane
1,2-Diisobutylene Oxide
2,3-Diisobutylene Oxide
EP-201 (a diaryl diepoxy carboxylate)
Styrene Oxide
2,2,3,3-Tetramethyl Butyraldehyde
Vinylcyclohexene Dioxide
Vinylcyclohexene Monoxide
(1,2,-Epoxy-4-Vinylcyclohexane)

Up until now there had been no practical way to make peracetic free of the

(*Continued on page* 80)

Simplified flow-diagram of new process contrasted with conventional acetic acid process.





The "neck" between the pump chamber and motor area of this new Chempump acts as a thermal barrier to the transfer of heat from the pumped fluid to the relatively cool fluid circulating in the rotor chamber. Further motor section cooling is achieved by the heat exchanger girdling the stator.

New *Chempump* handles hot fluids

- **No seals . . . no stuffing boxes**
- **No fluid loss or contamination**
- **No lubrication . . . 90% less maintenance**
- **Just one moving part**

Now you can pump heat-transfer fluids, hot vegetable and mineral oils, silicone fluids—without leakage . . . without contamination, even under extreme vacuum or pressure! This new Series T *Chempump* ends the problems of transferring or circulating such hot "problem" fluids as Dowtherm, Arochlor, fatty acids, vegetable oils or others.

Pump, motor and heat exchanger are combined in a single, compact hermetic package. Pump impeller and rotor are an integral unit—*Chempump's* only moving part.

Fluid enters the rotor chamber, and is completely isolated from the stator section by a corrosion-resistant, non-magnetic liner. A portion of this fluid is continually re-circulated in the rotor chamber and through an integral heat exchanger by an auxiliary impeller, to cool the motor. Pressure balance at the "neck" prevents intermixing of fluid in the motor section and fluid in the pumping section while the *Chempump* operates at a steady state. Motor windings keep cool, yet there's no heat loss of pumped fluid.

No shaft-sealing device is needed. Normally hard-to-handle fluids—hot, volatile, toxic, corrosive, explosive, radioactive—just can't leak or become contaminated.

Get the facts. For details and application data, send for new *Bulletin 1040.*

SPECIFICATIONS

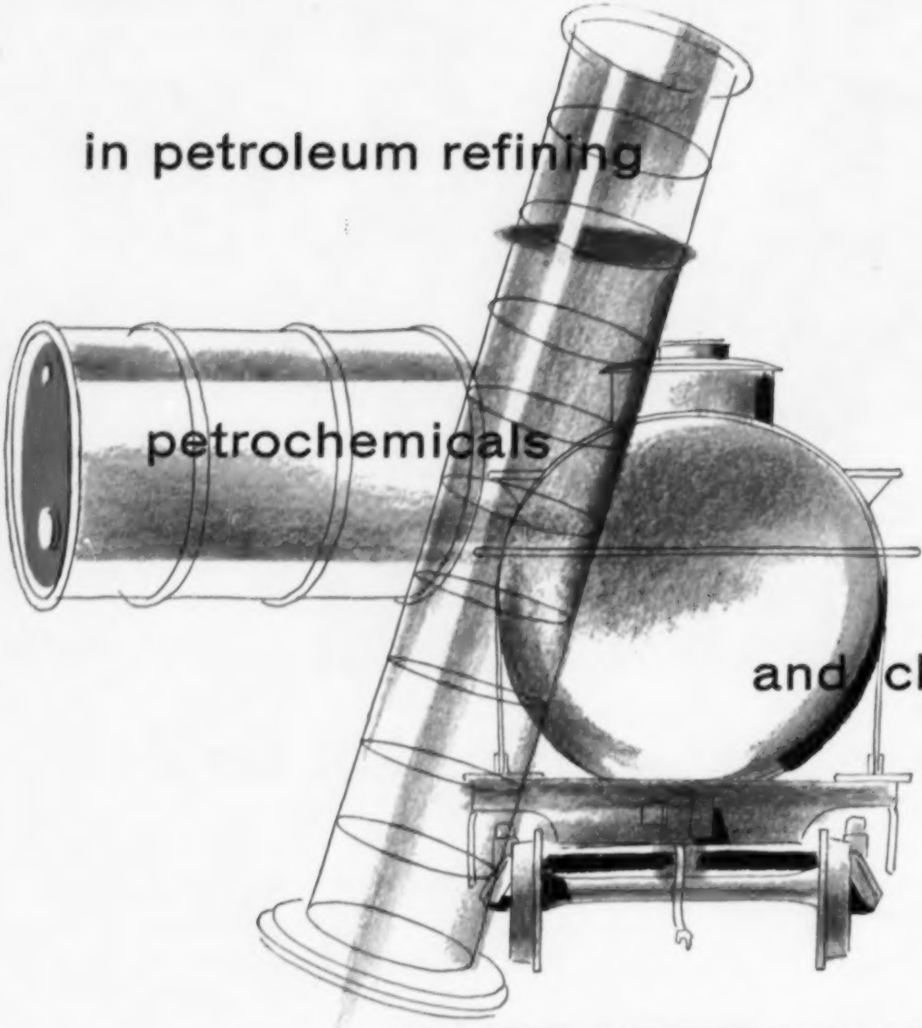
Horsepowers	¾ to 7½, in 6 models
Heads	to 190 feet (maximum)
Capacity	to 200 GPM (maximum)
Materials of construction*	cast iron, cast steel, 300-series stainless steel
Temperature limit*	1000°F.
Pressure limit*	150 psi

**Standard. Designs for higher temperatures or pressures, or using other construction materials, available on special order.*

Chempump

First in the field . . . process proved

CHEMPUMP CORPORATION • 1300 E. Mermaid Lane • Phila. 18, Pa.



FLUOR OFFERS A COMPLETE ENGINEERING AND CONSTRUCTION SERVICE

from project concept . . . to finished plant

Neither raw-material source nor end-product classification limits Fluor's services to the process industries. A completely integrated organization and the broad experience of its staff enable Fluor to undertake projects of any size . . . any complexity . . . any process . . . at any location. Fluor's ever-growing reservoir of experience is gleaned from all the industries and fields it serves: petroleum refining, petrochemicals, chemicals, electric power, heavy construction, and atomic energy. We can thus bring to bear many new ideas and techniques on the problems of any one industry.

And since we are equipped to accomplish *every* phase of a new facility—research, design, engineering, construction—we think in terms of the *entire project* rather than of an isolated part. The result is a 65-year record of successful plants with low initial investment and minimum operating costs.

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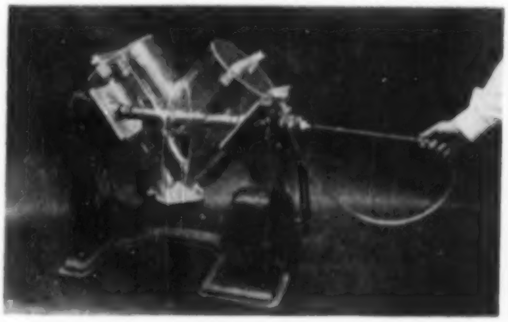

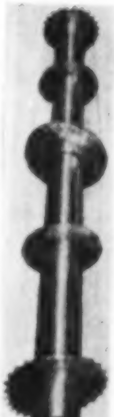

33 BLENDER EQUIPPED WITH LIQUID-SOLIDS INTENSIFIER. Data-file sheet with capacities and dimensions describes Patterson-Kelley liquid-feed blender (patent pending). Equipment consists of twin shell unit which rotates at 13.7 to 25 rev./min. Surrounding the axle tube is the intensifier bar, on which are mounted several discs, one offset. Stainless steel wires are strung parallel to the axle tube. In operation, cage assembly rotates at speeds up to 1500 rev./min., offset disc disperses liquid feed into larger mass of finely divided solids, and wire cage assembly breaks up lumps. Liquids up to 250° F. and water contents of final blend up to 30% have been handled satisfactorily. Average time for blending runs from 10 to 15 min./batch. Cost of unit approximately 25% more than standard models.

(Continued on page 68)

TURN THIS PAGE TO RIGHT FOR MORE . . .

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Merely encircle numbers on cards to get literature desired. On advertised products in front of magazine, fold this page out to right. For those in back, fold card strip again to right, where card strip is scored for detaching.

products-

advertised in this issue

IFC Technical Representative. His training plus practical experience enables him to give you the best information available in selection & use of chemicals in your processing. A call to Carbide and Carbon Chemicals Co. will bring him to you.

3R Sifter. A chemical plant sifter with a stainless steel product zone, the model M Bar-Nun rotary sifter has every desirable feature wanted on a screening job. B. F. Gump Co.

4-5A Nordstrom Valves. Ninety basic innovations are claimed for the Rockwell-Nordstrom valve. Some are listed. Valves are lubricant sealed for positive shutoff. Rockwell Mfg. Co.

6A Demisters. Thruput in distillation equipment can be increased by using Yorkmesh demisters. Send details on your operating conditions & Otto H. York Co., Inc. engineers will undertake to improve performance of existing equipment.

8-9A Filters. Sparkler Mfg. Co. describes in detail why their original, horizontal plate design & flow principle gives high efficiency with various filter aids. Easily dismantled for cleaning all inner surfaces providing complete sanitation.

10L Turbo Feed Pumps. Matched pump, turbine & governor are compactly designed & precision built as an integral unit. Minimum size, low steam consumption. Ranges to 800 gal./min. J. S. Coffin, Jr., Co.

11A Crystallization Equipment. Developed by Krystal & made available through Struthers Wells Corp., equipment for production of better crystal products at low cost. Staff available for consultation or laboratory tests.

12A Refrigeration. Check the six cost-saving advantages of water vapor refrigeration set forth by Ingersoll-Rand using their steam-jet coolers.

13A Diaphragm Control Valves. Kieley & Mueller, Inc. valve design features & production standards invite comparison, pointing up the superior value claimed for these valves.

14A Thorium. Davison Chemical Co. announces an expanded program in cooperation with Rare Earths, Inc. for production, sale, research & development of thorium, cerium & other rare earth compounds.

15A Metering Pump. Lapp Insulator Co., Inc. auto-pneumatic Pulsafeeder provides continuous automatic processing of liquids not satisfactorily handled by plunger-type metering pumps. Adjusts from zero to capacity. No stuffing box.

16L Force Balance Transmitter. Fischer & Porter Co. announce the first of their 1500 Series—the No. 1575. For converting from differential pressure to a 3 to 15 lb./sq.in.g. signal. Provides accurate instantaneous transmission of flow rate.

17A Mixers. Years of experience in the design of continuous mixers for extraction, blending & spent solvent recovery have resulted in the Turbo-Mixer from General American Transportation Corp. Another petrochemical operation shown in flow sheet.

18L Industrial Pumps. Named Verti-Line, these pumps are the product of Layne & Bowler Pump Co. Units are designed & engineered for booster service, fire protecting, cooling, general pumping service of water & other liquids.

19A Laminated Tape. Called Plicoflex No. 340 a laminated tape for protection of pipelines against corrosion. Available in black, white & six brilliant colors it can do an extra job by eliminating frequent costly painting. Uniform thickness. Plicoflex, Inc.

20A Feeder. Called MIKRO Rotary Airlock unit provides ideal method of feeding free-flowing materials under pressure or vacuum while sealing in air or gas from passing on with materials. Available for low or high pressure use; capacities 100 to 15,000 lb./hr. Pulverizing Machinery Div., Metals Disintegrating Co., Inc.

21A Tank Vent & Flame Arrestor. Introduced by Black, Sivalls & Bryson, Inc. a lightweight unit featuring high capacity pressure & vacuum relief, single seal, superior design.

22A Valves. Efficiency of these valves indicated by ability to hold to 25 microns absolute pressure after 2 years on vacuum service. Sizes 1/2 to 12 in. in various body & trim materials. Crane Co.

23A Engineering & Construction Services. Blaw-Knox Co. have years of experience in design, engineering, procurement, construction & initial operation of all types of process plants in addition to remodeling & modernizing existing units. Consultation available.

24L Teflon Gaskets & Accessories. U. S. Gasket-Belmont Packing Co. Teflon Chemiseal gaskets & accessories for chemical piping listed in ad are briefly described & illustrated with cutaway views.

25A Process Equipment. Schutte and Koerting manufacture jet apparatus, rotameters & flow indicators, valves, heat transfer equipment, gear pumps. Information available on individual units.

26A Limestone. The Norfolk and Western Railway can tell you where to locate a deposit of 100 million tons of limestone strategically placed & on their line. Inquiries treated as confidential.

27A Filters. Built to meet exacting requirements of process engineers Eimco Corp. filters give guaranteed performance. Wide range of types includes vacuum & pressure designs.

28A Entrainment Separators. To get cleaner, more economical liquid/vapor separation investigate Schuylernit units. Recommended for use in vacuum & flash towers, gas absorbers, evaporators, etc. Schuyler Mfg. Corp.

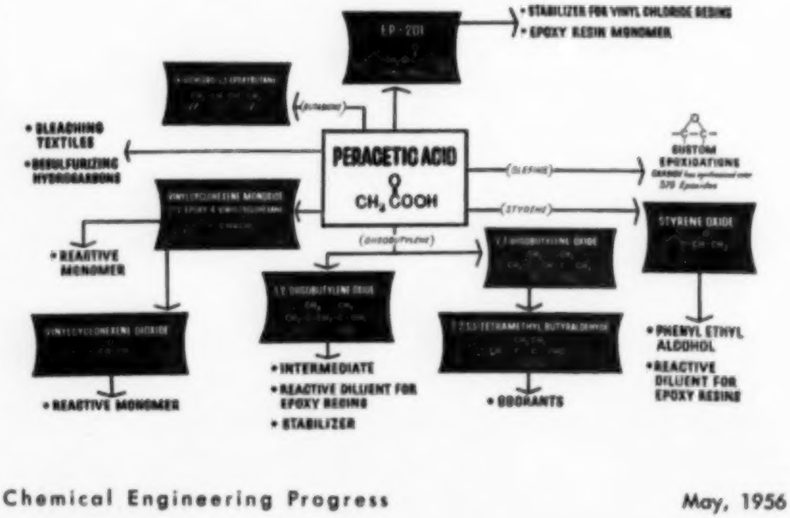
29A Impervious Graphite Equipment. Prices of standard, quantity-produced Karbate impervious graphite equipment from National

DEVELOPMENTS of the month (Cont.)

34 DATA SHEETS ON EIGHT NEW EPOXIDES. Carbide & Carbon Chemicals is making available, from a special pilot plant, experimental quantities of eight new epoxides produced with peracetic acid. Listed on the chart, these epoxides offer a number of possibilities to engineers engaged in the production of synthetic resins, odorants, plasticizers, or other organic chemical development or manufacture. Essentially new as raw materials, since their present availability and economic attractiveness is based in peracetic produced by a new process developed by Carbide (see story p. 64), a full scale plant to produce them is expected to be ready within two years. The data and samples available through the data service post card offer the first step toward consideration and trial for possible use in your existing or contemplated processes. For data sheets on all eight in the chart, circle number 34 on Data Post Card.

(Continued on page 69)

PERACETIC ACID AND DERIVATIVES



Carbon Co. compare favorably with those of materials less resistant to corrosion. Delivery usually from stock.

30A Packaged Agitator. Said to be the complete solution of your fluid agitator problems through one centrally-controlled, thoroughly responsible source. See list of features. Philadelphia Gear Works, Inc.

31A Ammonia Plants. Foster Wheeler Corp. are specialists in the design, fabrication & erection of all phases of process & equipment. Seven plants erected by them now produce 1,035 tons/day of ammonia.

32L Mixer. Read Standard Corp. mixer has a unique split-level bowl which provides greater surface ratio to volume of mix. Line of paper coating mixers supplied for manual or hydraulic discharge in 150 to 750 gal. working capacities.

33A Metering Pump. The Delta P pump a product of the Milton Roy Co. provides practical downhill metering (controlled volume pumping from higher to lower pressures). Particularly adaptable for use with corrosive or hazardous liquids.

34A Plug Valves. Lubricated plug valves from Wm. Powell Co. are available in all types of bronze, iron, steel, as well as semi-steel. Feature quick & positive operation. Require only quarter-turn to open or close.

35A Carbon & Graphite Products. Graphite electrodes, anodes, molds & specialties available from Great Lakes Carbon Corp. are carefully packaged adding another plus factor to the line.

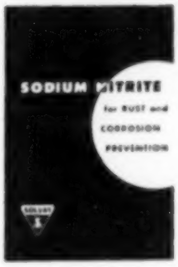
36L Cooling Tower. Marley Co. specialists in water cooling supply you towers with consistent ability to deliver cold water at specified temperature & volume. Their facilities devoted 100% to science & techniques of water cooling.

37A Heat Exchangers. You can save work, engineering costs, delivery time, repairs, & initial cost by using Whitlock Mfg. Co. standardized heat exchangers. Various types illustrated.

38A Lithium. A check list for the use of lithium researchers is offered by Lithium Corporation of America, Inc. Check your particular field of interest & appropriate literature will be sent you.

39A Process Equipment. Now you can test out your theories in Bartlett-Snow experimental units available for rental or purchase. If inconvenient to run in plant tests arrangements may be made to run them in their laboratory in presence of & direction by your technicians.

DEVELOPMENTS OF THE MONTH *(Continued)*



35 SODIUM NITRITE. A new edition of a 15-page booklet on Sodium Nitrite for rust & corrosion prevention is available from Solvay Process Division of Allied Chemical & Dye Corp. Illustrated, the booklet contains up-to-date data on uses of sodium nitrite for corrosion prevention.

36 COOLING TOWERS. Construction & operational details of the new Foster Wheeler induced draft cooling tower are described in a special bulletin. In addition to a three-dimensional wash drawing of the tower cell, the publication includes perspective drawings of major equipment features including water-mixer drift eliminators, full cone spray nozzles, double diamond fill racks, etc.

(Cont. on page 70)

Numbers without letters indicate data available as described in Data Service "Briefs." Numbers with letters refer to further data concerning products advertised in this issue. Letters indicate position of advertisement on page (if more than one on a page)—L, left; R, right; T, top; B, bottom; A indicates full page; IFC, IBC, and OBC are cover advertisements.

Postage Will Be Paid by Addressee

BUSINESS REPLY CARD
First Class Permit No. 48890, Sec. 34.9, P. L. & R., New York, N. Y.

No Postage Stamp Necessary If Mailed in the United States

CHEMICAL ENGINEERING PROGRESS
25 West 45th Street
New York 36,
New York

Postage Will Be Paid by Addressee

BUSINESS REPLY CARD
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No Postage Stamp Necessary If Mailed in the United States

CHEMICAL ENGINEERING PROGRESS
25 West 45th Street
New York 36,
New York

products-(Cont.)

advertised in this issue

40A Rotary Vacuum Filters. Higher yield in your case may mean one of several things. Filtration Engineers, Inc. units are custom-designed continuous vacuum filters all designed to improve your yield.

41A Porcelain Raschig Rings. Two important reasons make these Raschig rings the best bet for your tower packing—purity & strength. Bulletin available containing description & specifications. Lapp Insulator Co., Inc.

42L Panarez Hydrocarbon Resins. Materials provide product improvement for articles such as shoe soles, floor tile, wire covering, tire, & others. Available in any color from Barrett No. 1 to 18. Softening point from 40 to 300° F. Pan American Chemicals Corp.

43A Process Equipment. The Pfaudler Co. gives you some quick facts about their services & equipment in a reproduced page from Corrosioneering News. Includes much pertinent information.

44A Hydrator. You can reduce your burden in dehydration of pure dry crystals by installation of a Sharples Corp. Super-D-Hydrator. Listed are two important facts to consider in your planning.

DEVELOPMENTS of the month (Cont.)

37 ELECTRIC MOTORS. "The New L. A. Line of Electric Motors," a two-color bulletin from The Louis Allis Co., includes photos & information on the new open drip-proof, as well as enclosed & explosion-proof, electric motors manufactured by them. Includes cutaway views plus ten explanatory technical drawings & graph which provide essential data on performance & application features.

(Continued on page 72)

45A Thin Wall Tubing. A new answer to design problems is given by using Superior Tube Co. large O.D. thin wall tubing available in most materials & sizes to 1⅛ in. O.D., .035 in. wall maximum; Monel & certain stainless steel in sizes 2½ in. O.D. & .025 in. wall maximum.

46L Metallic Filter Cloth. Newark Wire Cloth Co. materials do stop solids. Wedge-shaped openings allow only filtrate to pass through. Cloth is reversible, both sides are identical.

47R Spray Dryers. Included in the Nerco-Niro line are centrifugal atomizers to handle capacities from a few to 36,000 lb./hr. Special designs available for abrasion & corrosion resistance as well as other uses. Nichols Engineering & Research Corp.

48A Process Equipment. Versatility in design, engineering & fabrication of these units is guaranteed by past performance in all processes. Acme Coppersmithing & Machine Co. Investigate.

170A Ion Exchange. Cut process costs by use of the ion exchange method. If yours is a problem of recovery, concentration or separation of chemicals in solution a Permutit Co. process can help you.

50A Turbo Dryer. A closed circuit system with recirculation of inert gases, conditioned air & vapors which offers unusual advantages. Small gas makeup required because of negligible pressure drop through unit. Wyssmont Co., Inc.

55A Coating Manual. Protect your plant & equipment by use of ATD paint available from U. S. Stoneware Co. Recent manual is filled with data to make your battle against corrosion easier.

56L Conveyor Dryer. Lowest cost per unit of product dried is the claim for every National Drying Machinery Co. unit. Unique unit construction makes size & productive capacity unlimited.

57A Valves. Cooper Alloy Corp. stainless steel valves embody design features originating from suggestions of countless experienced users evolved at in plant clinics. "75 Questions," a booklet of selected questions asked at such clinics is available.

58A Chlorination. Heat Transfer losses resulting from slime formation on condenser & heat exchanger water-side surfaces can be eliminated by chlorination of cooling water. Technical information available. Wallace & Tiernan Inc.

59A Process Plants. The construction of hydrocarbon processing plants, gas producing & chemical plants as well as process equipment has been the chief interest of Girdler Co. for many years. Take advantage of their experience in planning your process facilities.

60L Dust Control. Dust & noxious fumes resulting from acidulation at the mixing source yield to control when a Simpson Mix-Muller is in use. May be adapted for heating, cooling or chemical reaction while mixing. National Engineering Co.

61A Autoclave. Called Dispersimax this new autoclave is the answer to maximum gas dispersion. Extensive tests show device will decrease reaction time. Use frequently results in reactions occurring at lower pressures. Autoclave Engineers.

62A Heat Transfer Equipment. Optimum performance at minimum cost is the result where fabricator know-how, know-when & know-where are put into a job. M. W. Kellogg Co. long experience in the field guarantees such performance.

65A Process Pumps. Named Chempump, unit handles hot fluids without leakage. Impeller & rotor are an integral unit & the only moving part. Specifications listed. Chempump Corp.

66A Engineering & Construction Service. Fluor Corp., Ltd. offers these services to those in the petroleum refining, petrochemicals & chemicals fields. Complete service from project conception to finished plant.

71A Spray Dryer. A new semi-works spray dryer said to be compact, give high yield, easy to clean available from Bowen Engineering, Inc. Fully prefabricated it requires only hours to erect. Drying temperatures 200 to 750° F.

73A Process Filters. You can relax with confidence that your filtration processes are efficient, trouble-free & profitable by installation of Process Filters, Inc. units. Information available.

75A Process Equipment. Whatever your requirement be it a single boiler to a huge tower, Badger Mfg. Co. is prepared to supply it. Shop facilities available for building & testing needed equipment. Invite their bid on your project.

77A Stainless Steels. Specialized service available from G. O. Carlson, Inc. in the field of stainless steel either in plates, bars, sheets & other shapes because stainless steel is their only business.

79A Pipe Insulation. Called Unibestos this pipe insulation for chemical plants is the product of Union Asbestos & Rubber Co. Single-layer Unibestos easily installed on the job. Available in sectional form through 44 in. O.D.

80L Heat Exchangers. Units fabricated from stainless steel & standardized for quick delivery are product of Doyle & Roth Mfg. Co., Inc. ASME standards govern fabricating procedures.

81A Steel Belt Conveyors & Coolers. From Sandvik Steel, Inc. units which provide a continuous way to process hot chemicals. Handle materials to temperature of 1900° F. Other uses for units without water-bed cooling arrangement.

84L Heat Transfer & Process Units. Several units in line of Manning & Lewis Engineering Co. are illustrated. Fabricators work with ferrous & non-ferrous materials.

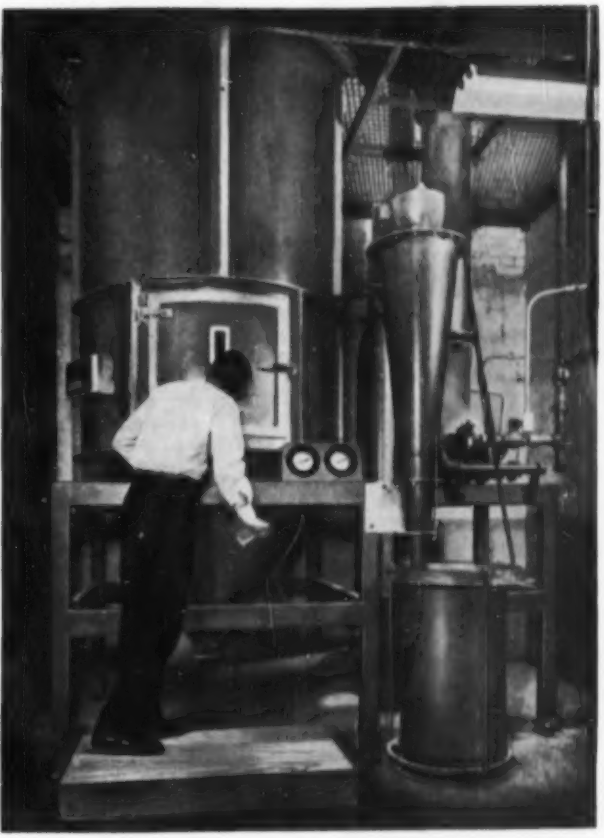
(Continued on page 72)

new

BOWEN SEMI-WORKS

SPRAY DRYER

- ★ COMPACT
- ★ HIGH YIELD
- ★ EASY TO CLEAN
- ★ LOW OPERATING COSTS


From one position the operator can observe the chamber interior, read the inlet and outlet temperatures and adjust the air heater.

● **At last a fully prefabricated spray dryer requiring only hours to erect.** The new reasonably priced Bowen Semi-Works Spray Dryer makes available a small, compact unit requiring a working area of only 7 x 9 feet, completely prefabricated and transportable through usual factory openings. Surfaces in contact with the product and feed material are of stainless steel thruout. Drying temperatures are variable between 200°F and 750°F to accomodate a wide variety of materials.

An interesting illustrated booklet, Bulletin 36, is available. Send for it today.

Mail Coupon for Free Literature

BOWEN ENGINEERING, INC.
NORTH BRANCH 13, NEW JERSEY

Recognized Leader in Spray Dryer Engineering Since 1926

BOWEN SPRAY DRYERS
***Always* Offer You More!**

BOWEN ENGINEERING, INC.
NORTH BRANCH 13, NEW JERSEY

Please send me Free Literature on Bowen Semi-Works Spray Dryer.

NAME____________________

COMPANY____________________

ADDRESS____________________

CITY__________ ZONE_____ STATE_______

products-

advertised in this issue (Cont.)

85A Chromium-nickel Stainless. Use of this material frees hopper from source of constant trouble in process units. Easy to clean & keep clean metal is sanitary & minimizes maintenance. International Nickel Co., Inc.

87A Shipping Containers. National Lead Co. now has available a line small containers for shipping & mailing of radioactive materials. Said to be easy to handle & easy to decontaminate. Meet ICC-55 requirements.

88L Corrosion Protection. Coating material from Atlas Mineral Products Co. offers plant wide protection from corrosion. On-the-spot technical advice service available from beginning to end of job.

89A Drying Equipment & Textile Machinery. Manufactured by Proctor & Schwartz, Inc. this machinery assures you of uniformity of product, longer life, less downtime, & manufacturer's service.

90L Centrifugal Pumps. Eastern Industries, Inc. model D-11 is the smallest, close-coupled, single-stage centrifugal available. Fabricated in many materials Eastern pumps range from 1/8 to 3/4 h.p.; capacities to 70 gal./min.; pressures to 65 lb./sq.in.

91A Job Opportunities. See the long list of opportunities awaiting you at the Caltech Jet Propulsion Laboratory. If you qualify contact them today.

92L Heat Exchanger, Steel & Alloy Plate Fabrication. Illustrated is a 42-ton stripper with diameter of 6 ft. I.D., height 133 ft. 3 in., shell thickness 3/4 in. Downingtown Iron Works, Inc. are prepared to supply your specific needs.

94L Tantalum. If this is a metal you need you can't afford to do without it. Fansteel Metallurgical Corp. can evaluate the pros & cons as applicable to your process enabling you to reach your own conclusions.

95R Electrometer. For stable amplification of low-level d.c. signals use a Curtiss-Wright Corp. dynamic capacitor electrometer. Measures current as low as 10^{-16} amp. High input impedance.

96L Centrifuges. Modern units for continuous chemical processing available from Centrico Inc. made by Westfalia Separator A.G. For use in the chemical, pharmaceutical, food processing & oil industries.

97L Filtration Units. Ranney Method Water Supplies, Inc. now can offer a program for every community & industry. Engineering research makes available latest modern supply techniques.

97R Structural Plastics. Whenever you need fabrications or components with long service life, high impact strength, light weight, & chemically inert to 170° F. consult American Agile Corp. pioneers in the field.

98L High Alloy Castings. In thirty years in the field Duraloy Co. has initiated many firsts in high-alloy castings. All products carefully controlled & quality tested.

99R Tubular Filters. Industrial Filter & Pump Mfg. Co. tubular filters have important new features due to flow from inside of tube. Units are simple to operate & easy to clean.

A.I.Ch.E. MEMBERSHIP—
Brochure—"Know Your Institute"—tells objective aim and benefits to chemical engineers who join this nation-wide organization, includes membership blank. Circle number 39 on Data Post Card.

101R Process Equipment. Goslin-Birmingham Mfg. Co., Inc. is prepared to shoulder the entire load from design to finished product if you have a processing problem. Engineers always at your service.

102L Laboratory Stirrer. Electronically controlled, a laboratory stirrer equipped with special Bodine motor & Thyratron tube control. Variable speed at full torque. 1/50 h.p. motor may be run in either direction. Ace Glass Inc.

103R Swing Joints & Assemblies. Five reasons for the superiority of these parts, are listed. Line is complete to meet every need. Sizes 1 through 4 in. All steel or malleable iron. Barco Mfg. Co.

√ CHECK *your Data Service requests on the handy postcard on page 67 to*

▶ GET *up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.*

104L Liquifiers. Refrigerated liquifiers for chlorine & other chemical vapors are designed & built with guaranteed performance by Richard M. Armstrong Co. Units are both vertical & horizontal.

105R Dryers. C. G. Sargent's Sons Corp. will build dryers for you with any desired number of trays, for use in drying wet powdered, sensitive or unstable materials required to be dried slowly & with utmost care.

107A Stainless Steel & Alloys. Sun Shipbuilding & Dry Dock Co. are specialists in problems concerning fabrication of stainless steel & other special alloys. Discuss your problems with their engineering staff.

109R Rotary Pumps. Called Gearex, a line of rotary pumps from Sier-Bath Gear & Pump Co., Inc. for handling liquids from 100 to 500,000 SSu, 1 to 50 gal./min. at 250 lb./sq.in. for viscous liquids, 50 lb./sq.in. for water.

110L Silicone Defoamers. Increase your productive capacity; reduce process time; eliminate waste & boil-over hazard by using Dow Corning Corp. silicone defoamers. Two types. Samples available.

111L Tower Packing. Two types—Berl saddles & Raschig rings made in Knight-Ware acid-proof stoneware & porcelain. Available in sizes 1/4 to 2 in. in both types. Maurice A. Knight.

111R Woven Wire Screens. You can stop needless waste of corrosion in woven wire screens by specifying screens from Cleveland Wire Cloth & Mfg. Co. Available in metals & alloys such as stainless steel, Monel, etc.

112TL Processing Problems. Artisan Metal Products Inc. invite you to investigate their engineering & manufacturing approach to your special process problems which includes a staff of chemical engineers plus a complement of mechanical engineers & facilities for manufacturing.

112BL Liquid Flow Slide Rule. Instrument for accurate solution of flow problems in a matter of seconds. For both turbulent & laminar flow. Information available from C. J. Major Co.

112BR Optical Pyrometer. A simplified instrument which reads temperatures directly. Ranges from 1,400 to 7,500° F. or in equivalent Centigrade calibration. Pyrometer Instrument Co.

(Continued on page 74)

Developments of the Month (Continued)

38 NEW HEAT EVAPORATORS transform sea water into fresh water at no fuel cost by utilizing waste heat from diesel engines or gas turbines. Information on five models with capacities from 300 to 2,100 gal./hr. is available in Cleaver-Brooks brochure "Fresh Water by the Ton." Brochure contains a comparison chart showing savings possible with Cleaver-Brooks waste heat evaporator as compared to vapor compression or multi-effect evaporators and barged-in water. Tells how off-shore drilling operators can save up to $25,000/yr. by producing fresh water from sea water on board at no fuel cost.

(Continued on page 74)

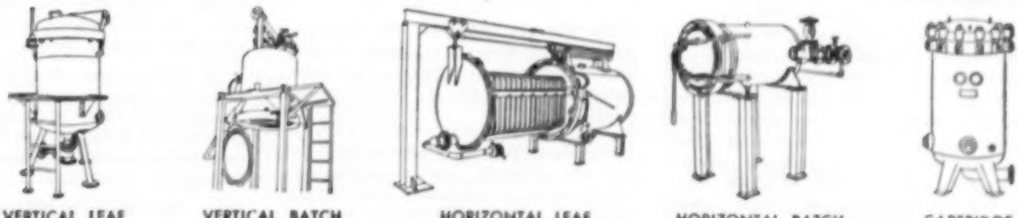
this man's plant is equipped with...

PROCESS FILTERS

Take a tip from this man . . . relax with the confidence that your filtration processes are efficient, trouble-free and profitable . . . with Process Filters.

If you would like more information . . . contact Mr. Edward A. Ulrich, Vice President.

See Process Filters in the Bowserama in your city . . . . . watch for announcement of dates.



VERTICAL LEAF FILTERS — VERTICAL BATCH FILTERS — HORIZONTAL LEAF FILTERS — HORIZONTAL BATCH FILTERS — CARTRIDGE FILTERS

Ask about the time-payment plan for capital investments.

PROCESS FILTERS, INC.
1807 Elmwood Ave., Buffalo 7, N. Y.
A subsidiary of BOWSER, Inc.

Photo by Underwood & Underwood

products-

advertised in this issue (Cont.)

113R Steam Tube Dryer. Hardinge Co., Inc. has supplied the Ruggles-Coles units in various materials to protect against corrosion & contamination. Extra advantages of dryers mean continuous maximum output.

114B Towers. Half century of producing welded steel plate structures coupled with modern engineering & production equipment facilities make Posey Iron Works, Inc. recognized for towers of all kinds & sizes.

115R Steam Jet Ejectors. Elliott Co. type H ejectors illustrated made of Haveg, Permanite or similar corrosion-resistant synthetic resin material maintain vacuum. Stand up to most acids & aromatic compounds.

116TL Rectifiers. A line of reliable, efficient & easily maintained rectifiers called Sel-Rex, are the product of Bart-Messing Corp. Available in air or water cooled models & custom engineered to your specific needs.

116BL Proportioning Pump. Called Microflex, a chemical proportioning pump available in simplex & duplex styles, pressures to 60,000 lb./sq.in. & capacity 0.97 to 31.21 gal./hr. American Instrument Co.

117R Mixers. A complete line of mass & paste mixers available from Paul O. Abbé Inc. which guarantee top performance whether your job be simple or difficult.

Developments of the Month *(Continued)*

40 OXYGEN ANALYZER. The Hays Magno Therm oxygen recorder consists of analyzing section & remote recording section for continuous oxygen analysis of flue gases, fuel gas mixtures, process streams, inert gas mixtures, etc. The operation of the instrument depends upon the fact that oxygen is unique among common gases in that it is highly paramagnetic, while most common gases are diamagnetic.

The analysis cell consists of a pair of identical heated resistors mounted in a block of magnetic metal, so arranged that a strong magnetic field can be applied to the gas passage around one resistor. The oxygen-bearing gas is attracted into the magnetic field where it cools the resistor & loses its magnetism. Increased gas flow by this mechanism results in more rapid cooling of the resistor in the magnetic field than of that outside the field. A Wheatstone bridge arrangement isolates and evaluates the difference electrically.

This analyzer is said to be highly sensitive, rapid in response, & of high accuracy. Four continuous records can be provided on a single chart. Catalog available from Hays Corporation.

(Continued on page 76)

118L Laboratory Ware. Fabricated from Vitreosil (pure fused silica) these products have high chemical purity, high resistance to heat shock, good ultraviolet transmission & are low cost. Thermal American Fused Quartz Co., Inc.

119R Heat Exchanger. Fabricated from Impervite impervious graphite this cross bore heat exchanger represents a major innovation for practical solution of corrosive heat exchanger problems. Falls Industries, Inc.

120L Power Package. Called Varidrive this U.S. Electrical Motors Inc. power package includes an induction motor, variable speed drive & gearing to make a complete variable speed power source.

120TR Swing Check Valve. Said to be revolutionary a swing check valve from Greenwood Valve Div., Vernon Tool Co., Ltd., which eliminates the disadvantages of knocking or chattering. Sizes 2 through 12 in.

121R Pumping Progress Report. This report of interest to chemical engineers gives you details on how to increase pumping efficiency in your plant. Aldrich Pump Co.

122TL Jet Mixer. Claim for this jet mixer is that it gives 3 kettles to 2 previously obtained. No vortex & no foam. Good particle size makes for stable product. Hermas Machine Co.

122BL Laboratory Equipment. Called Metalab laboratory units are completely versatile, functional & adaptable to future operations. Metalab Equipment Co.

123TR Sprocket Rim. Babbitt Steam Specialty Co. has redesigned their adjustable sprocket rim with chain guide making any valve accessible from the floor.

123BR Pulverizer. If you require ultrafine grinding investigate Schutz-O'Neill Co. Superfine units. Six sizes range from 7½ to 125 H.P. with grinding chambers 12 to 28 in. in diameter.

124TL Rotary Presses. In addition to rotary presses with capacities 65 to over 5,000 tablets/min., the Arthur Colton Co. line includes mixers, granulators, & ovens for high production at low cost.

124BL Phenolic Laminates. For corrosion resistance, for electrical insulation cut costs with Bonate glass reinforced polyester, epoxy, phenolic laminates. Carl N. Beetle Plastics Corp.

125TL Glass Tubing. Whatever your job you get maximum precision when you specify precision bore tubing from Wilmad Glass Co., Inc. Made in various shapes & sizes. Special shapes available.

125BL Spray Nozzles. Thousands of standard industrial spray nozzle types & sizes may be selected from the line of Spraying Systems Co. Fabricated from all materials.

125TR Filters. Ertel Engineering Corp. filters for many uses some of which are illustrated & detailed. Bulletins available.

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▶ **GET** *up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.*

125BR Rotameters. Named Safeguard a line of rotameters from Schutte and Koerting. Some of their many other products are listed.

126TL Centrifugal Pumps. Records of high performance in handling highly abrasive & heavy mixtures of various types are claimed for Nagle Pumps, Inc. type T 4 in., frame 119 L horizontal shaft units. Catalog gives information on other types.

126BL Agitated Pressure Vessels. Available are units from 100 cc. to 5 gal.; pressures to 100,000 lb./sq.in. Body connections save you money. Pressure Products Industries.

127L Ion Exchange. If you have a water clarification problem Illinois Water Treatment Co. would be glad to make suitable recommendations for its solution. Consult them.

127R Hand Pyrometer. For quick, accurate temperature readings below 800° F. the Xactemp pyrometer equipped with rigid extension arm & surface tip thermocouple. Claud S. Gordon Co.

129BL Tank Meter. Called TANKoMETER instrument measures tank contents any distance away. Tank may be buried, elevated, open, closed, vented or under pressure or vacuum. Uehling Instrument Co.

129TR PVC Fittings & Flanges. A booklet containing facts on Tube Turns Plastics, Inc. PVC fittings & flanges may be had upon request. Includes properties & applications of PVC systems.

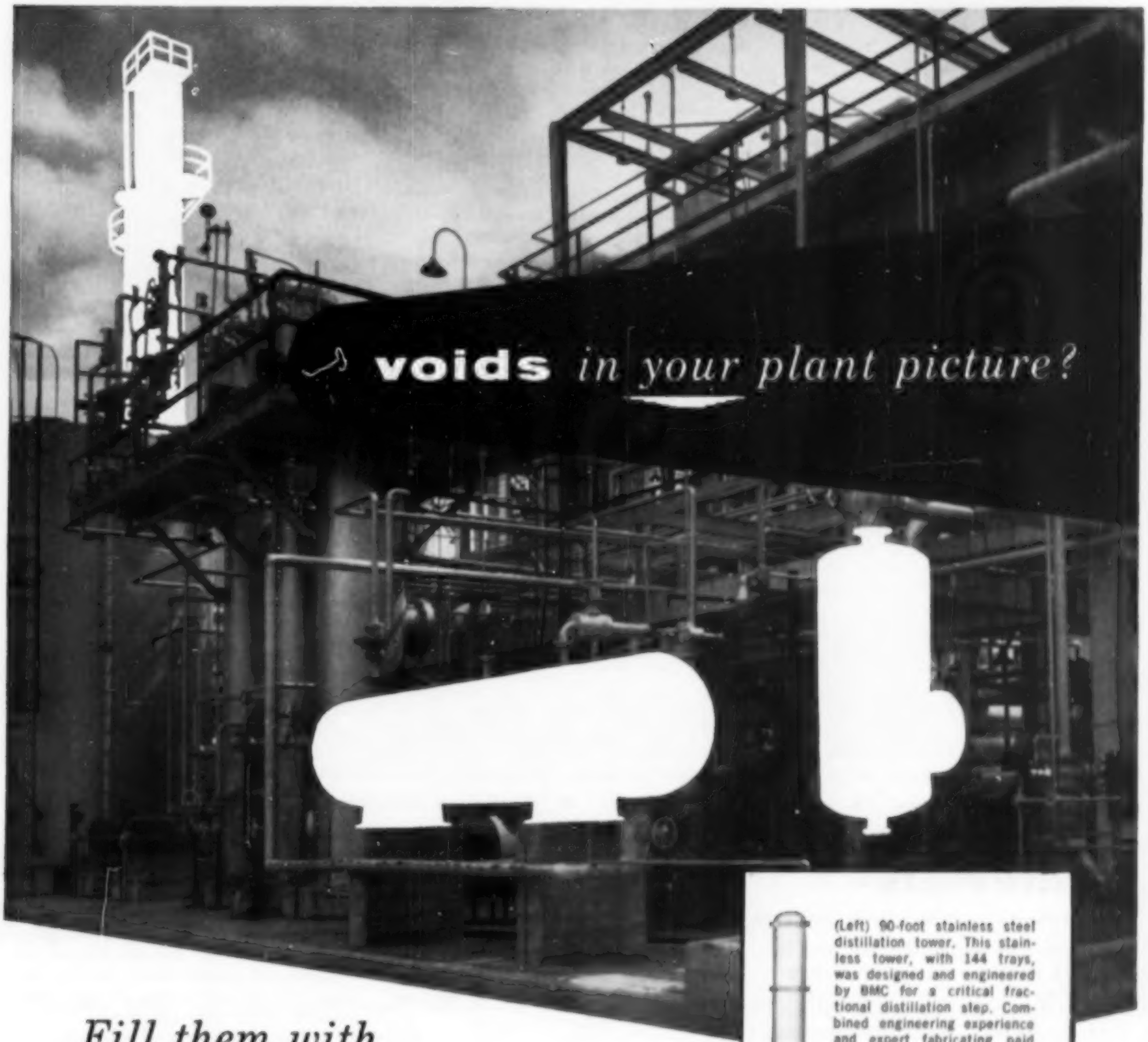
129BR Jet Equipment. Among the products of The Jet-Vac Corp. are steam jet ejectors, condensers, other vacuum equipment. Corrosion resistant parts interchangeable with standard parts.

131TL Rotary Pump. Available from stock a low-cost, low-volume pump for corrosive liquids. Capacities 1 to 10 gal./min. Pressures to 150 lb./sq.in. Stainless housings, impellers of various materials. Eco Engineering Co.

131BL Pipe Bends & Welded Assemblies. Units are fabricated from any ferrous or non-ferrous pipe or tube in size range from ½ to 8 in. iron pipe size. Illustrated is a special assembly. Rempe Co.

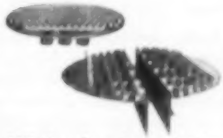
131TR Laboratory Glassware. Sharply etched, accurately manufactured, & double tested glassware, called the Diamond D Blue Line, is the product of Doerr Glass Co.

(Continued on page 76)



(Left) 90-foot stainless steel distillation tower. This stainless tower, with 144 trays, was designed and engineered by BMC for a critical fractional distillation step. Combined engineering experience and expert fabricating paid off for this customer — as it can for you.

A 2000-square foot vapor condenser for alcohol purification. Engineered and fabricated to close tolerances — typical of the type of job BMC has a reputation for doing right!



BMC has long been closely identified with fractionating tray design, development and manufacturing. Single unit or a carload, bring your tray problems where they'll get expert solutions.

Fill them with
BMC Process Equipment

New installation? . . plant expansion? . . modernization?

Whatever the reason you require process equipment — from a single boiling cap to a huge tower — BMC can supply it on *time*, on *quotation*, on *specification*.

Shop facilities and technical skill are available for building and testing the equipment you need . . . from whatever metal is required . . . in virtually any size . . . to any degree of complexity.

BMC experience costs no more. And you have the added assurance that your equipment is fabricated to the highest technological standards. What better reasons for inviting BMC to bid on your next project?

New catalog available. *Write for copy today.*

bmc

Badger Manufacturing Company

230 Bent Street, Cambridge 41, Mass.
60 East 42nd Street, New York 17, New York

ENGINEERS • CONTRACTORS • DESIGNERS • MANUFACTURERS

products-
advertised in this issue (Cont.)

131BR Bin Level Indicator. Use of the Roto-Bin-Dicator provides bulk material control under pressure or vacuum. Mounts outside bin at any desired angle. Bin-Flo Aerator assures flow of fine, dry materials tending to pack in storage. Bin-Dicator Co.

132L Controls. Selection of the suitable pressure or temperature control for any application is simplified by using the control catalog issued by Mercoid Corp. Ask for it.

132R Gages. Offered by Jerguson Gage & Valve Co. a special line of gages that weld right to the liquid containing structure to become an integral part of it. Welding Pad Gages of both Reflex & Transparent types.

133R Pumps. See the illustration of the 2-stage vertical pump designed & engineered by Lawrence Pumps Inc. to handle liquid chlorine. This is but one of the many types in their line. Bulletin available which lists summary of acid & chemical pump data.

134L Process Equipment. Regardless of size or type of your installation Alsop Engineering Corp. has filters, mixers, storage & mixing tanks to fit your requirements. Recommendations, quotations & information available.

134R Chemical Engineering Catalog. Whatever your needs CEC is organized to help you locate it in a minimum of time. Fully indexed in six ways it is a sure source of up-to-date information. Reinhold Publishing Corp.

135TR Sealing Service. Have you a stuffing box problem? Then consult Durametallic Corp. who have a staff of research & development engineers ready to help you without charge.

135BR Liquid Automation Equipment. Bowser, Inc. will furnish you with such equipment on a lease or progressive payment basis. Line includes meters, filters, etc.

136L Spray Nozzles. You'll get the right nozzles from Binks Mfg. Co. manufacturers of a complete selection. A size & spray pattern for every purpose. Special types if required. Catalog available.

137TR Dryers. Chemicals are dried quickly & economically in the steam-heated DehydrO-Mat, from Edw. Renneburg & Sons Co. who manufacture conventional dryers as well as the special unit.

137BR Attrition Mills. Single disc units used for granulating, fluffing, & many other purposes are made in 7 sizes from 8 to 44 in. diam. In addition to single & double revolving disc mills they offer many other types. Bauer Bros.

139L Atomic Power. If you belong to any one of the groups listed who work in the field of atomic energy communicate with Westinghouse Bettis Plant indicating your specific interests.

139R Job Opportunities. Mallinckrodt Chemical Works have substantially expanded their uranium division and have opportunities for suitable personnel. Write them if you are interested.

143TR Process Weighing. Glengarry Processes Inc. suggest their process weighing systems for timed, automatic weighing of dry components into the process stream. Afford precise formula control, versatility & rapid operation.

144L CO_2. From Liquid Carbonic Co. booklet titled "Applications Unlimited." The complete story on what CO_2 can do for you.

145R Chill-Vactor Units. For use by chemical & food processors Chill-Vactor units for using excess winter steam capacity for economical water chilling. Many other advantages. Croll-Reynolds Co., Inc.

IBC Controlled Volume Pumps. Milton Roy Co. in addition to their standard motor-driven controlled volume pump also manufacture the step-valve liquid end pump which offers dependable metering of process additives. Features listed. Selected bulletins available.

OBC Mixers. See the list of ways to cut seal costs in addition to advantages of savings using leakproof sealing of tank contents, plus easy seal replacement. Mixing Equipment Co., Inc.

Technical Literature • Technical Literature • Technical Literature • Technical Literature

materials-

1 Pyridine Derivatives. Another series of pyridine derivatives for research investigation offered by Reilly Tar & Chemical Corp. Include Diphenyl-4-Pyridylmethane, Diphenyl-4-Pyridylcarbinol, Penyl-4-Pyridylmethane, and Phenyl-4-Pyridylketone.

2 Ultraviolet Light Absorbers. A new 20-page booklet describes General Aniline & Film Corp. ultraviolet light absorbers called Uvinuls. Gives information on two established products in line & discusses two new ones.

3 Sodium. A 144-page book from Ethyl Corp. presents a critical evaluation of physical & thermodynamic properties of sodium. Material contained in book titled "Physical and Thermodynamic Properties of Sodium—A Critical Review," based on best available information in 1955.

4 Fatty Acids. Armour and Co. have available booklet called "The Chemistry of Fatty Acids." A comprehensive & convenient reference work for users of fatty acids & chemicals derived from fatty acids.

5 Methyl Vinyl Ketone. Data Sheet #512 from Chas. Pfizer & Co., Inc. outlines properties & suggested uses for this compound. Contains information on physical & chemical properties, a reaction chart, data on applications, storage, specifications, assay, etc.

6 Ethers & Oxides. Data on physical properties, solubilities, shipping, specifications & test methods, plus constant boiling mixtures of these materials are contained in a 64-page booklet titled "Ethers and Oxides," from Union Carbide and Carbon Corp. Book also contains list of literature & patent references.

Developments of the Month (Continued)

41 HIGH VACUUM DISTILLATION is achieved at low cost with a new line of modern stills designed for continuous operation by the Arthur F. Smith Company. Known as the Rota-Film Still, the new distillation processing unit features a sanitary, self-cleaning packaged unit capable of handling large capacities.

The "falling-film" type still provides for distribution of a uniform, non-spattering thin film layer over the entire evaporation surface, & is said to be easily operated under controlled or variable conditions.

(Continued on page 78)

7 Steels. Now being distributed by Allegheny Ludlum Steel Corp. booklet entitled "The Chromium-Nickel-Manganese Austenitic Stainless Steels." This is part of their Technical Studies series. Provides detailed information on stainless steels that use less nickel than the 300 series yet give high performance in many applications.

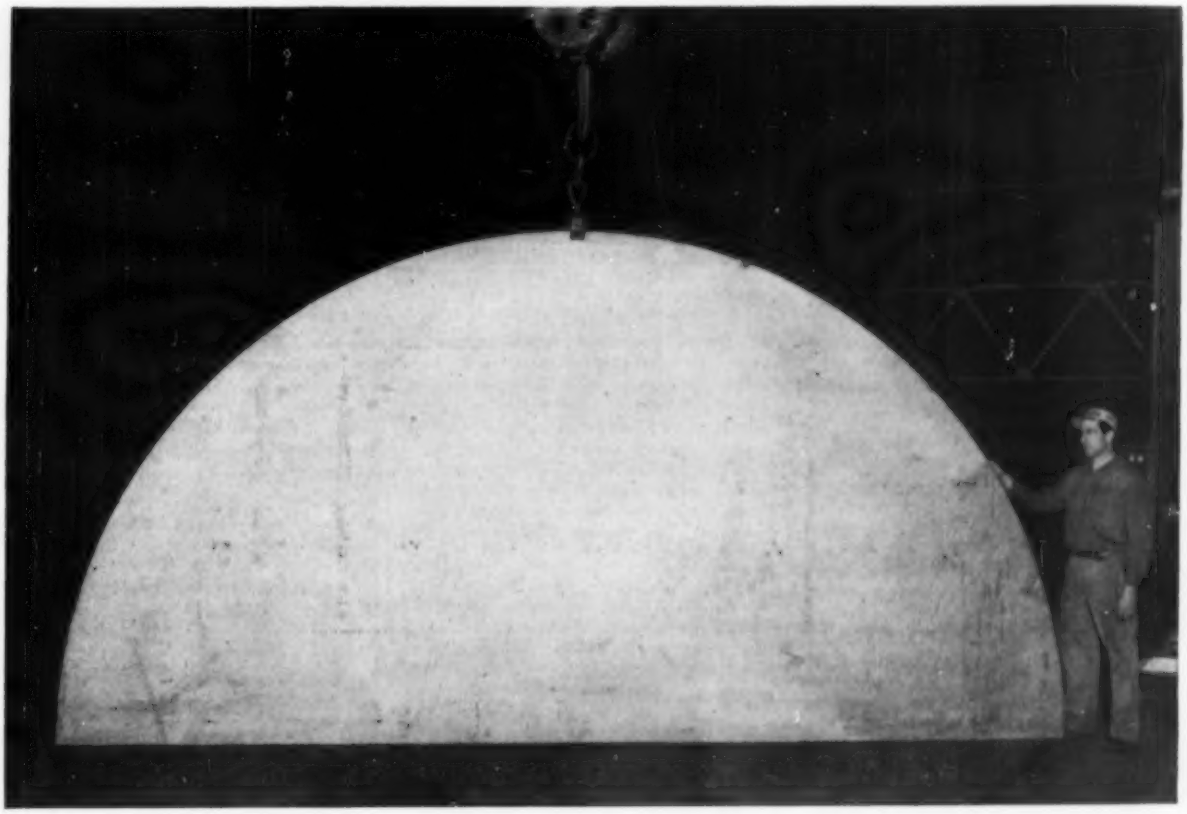
8 Acrylonitrile. A 3-page technical service bulletin discusses techniques of safe storage & handling of this material. Considered separately are construction materials, design of storage tanks, piping, storage precautions, etc. Includes 1-page data sheet insert listing of physical properties. Monsanto Chemical Co.

9 Neoprene Notebook. No. 68 in this series from E. I. du Pont de Nemours & Co. titled "The Language of Rubber . . . Part XV," on "Heat Resistance." Also considered are boating without bailing; handtruck tires, fire resistant conveyor belts for coal mines & many other phases of this subject.

equipment-

10 Submerged Combustion. Theory & practice of application of submerged combustion to industrial problems in evaporation, concentration, heating & waste dis-

(Continued on page 78)



Carlson specialized service keeps your costs low

Here's how Carlson *specialized service* in stainless plate worked on this job.

The illustration shows one of two segments of a tank head blank. Made of 1" thick, Type 302 stainless steel, the head blank measures 210" in diameter and weighs approximately 9000 pounds. Each segment was produced so accurately the customer did not have to "true up" the abrasive cut straight edges before welding the two segments together. This meant the customer had what he wanted, the way he wanted it—produced to his exact requirements.

And here's why you'll want this *specialized* Carlson service.

More than once we've helped a customer do his job easier, quicker and at lower cost by efficient planning and expert use of specialized equipment. This experience can work to your advantage, too. You can buy *exactly* what your specifications call for—and nothing more. This saves freight charges on material you cannot use. It also saves the cost and trouble of handling scrap in your shop. And you can set up a faster production schedule based on receiving what you want, when you want it.

Stainless steel is our *only* business—and we know it! Let us show you how this *specialized service* can help you. Your inquiry will receive prompt attention.

Stainless Steels Exclusively

G. O. CARLSON, INC.

THORNDALE, PENNSYLVANIA

Plates • Plate Products • Forgings • Bars • Sheets (No. 1 Finish)

District Sales Offices in Principal Cities

posal are covered in bulletin from Ozark-Mahoning Co. Case histories cited. Illustrations show equipment use. Heat release rates range to 384 million Btu/hr. without conventional heat transfer surface.

11 Electronic Computers. An applications manual from George A. Philbrick Researches, Inc. covers theory, performance & applications of these instruments. Includes equations & diagrams. Value in fields of analysis, design & development illustrated by advances in nuclear engineering, supersonics & automation. Additional illustrated bulletin on computers & accessories.

12 Flow Computers. Called Librascope a pressure-compensated totalizing unit which uses two double-disc integrators operating from static- & differential-pressure inputs to compute flow rate of gases from orifice measurements. Utilizes general equation for orifice measure, continuously extracts square roots, integrates & totalizes result on easily-read six-digit counter. Librascope, Inc.

14 Process Refractometer. An industrial process refractometer for monitoring of plant streams. Continuous measurement of differences in refractive index between flowing sample & reference liquid. Explosion-proofed, unit has sealed optical system, temperature compensation, and null balance system. Accurate to ±½%. Other instruments in line shown in illustrated booklet. Barnes Engineering Co.

15 Recording Systems. "Instruments for Modern Measurements," a brochure from Brush Electronics Co., describes & illustrates d.c. amplifiers, direct-writing oscillographs & accessories for measuring physical & electrical quantities. Up to six channels may be simultaneously recorded. Frequency response to 100 c.p.s., accurate calibration, precision attenuation, & signal expansion featured.

Developments of the Month *(Continued)*

42 ALLOY HEAT-EXCHANGE TUBING. A new 28-page brochure on cupro-nickel alloys for use in heat-exchange tubing discusses the uses and advantages of such tubing in difficult services. If heat-exchange tubing life now is measured in months instead of years, new tubing material should be considered. Where ordinary brasses fail because of pollution, brackish water, or excessive turbulence, switching to copper-nickel or Monel may be the answer.

Typical cases are cited where use of these alloys in heat exchangers resulted in substantial savings and better efficiency through longer tube life. Condensers, evaporators, and feed water heaters are the major types discussed, but other varied applications are also mentioned.

16 Centrifugal Molecular Still. A data sheet from Consolidated Electrodynamics Corp. accompanies an illustrated folder describing this still. Designed for use with heat-sensitive materials in molecular weight range of 250 to 1,200. Complete unit has capacity of 100 ml. to 1½ liters. Distillation rate 0.03 to 10.0 grams distillate/min. Pressure range 1 to 10 grams Hg abs.

17 Suction Centrifugal Pumps. A complete line of redesigned pumps are considered in bulletin from Deming Co. Includes performance tables & curves. Separate alloy liquid end construction available on most sizes for handling abrasive or corrosive liquids carrying lime, & other solids causing pump wear. Units range from 1 to 5 in. discharge size; capacities to 1,000 gal./min. at 75 ft. head; 100 gal./min. at 250 ft. head.

20 Air-Driven Motors. Two new models of air-driven motors for driving shafting equipped with drills or brushes for cleaning small straight tubes announced by Lagonda Div. of Elliott Co. For use where suspension type cleaners cannot be used. Use ⅜ in. hose with ¼ in. thread & require 15 to 20 cu. ft./min. of air at 90 lb./sq.in. gage.

21 Water Stills. Available from Barnstead Still & Sterilizer Co. new 48-page catalog on complete line. Comprehensive technical information. Models for laboratory to large industrial units. Includes descriptions, tabulations, etc. An essential reference book for users of distilled water.

22 Centrifugal Fans. Called Chicago & designed for a wide range of commercial & industrial ventilating, air conditioning & heating applications, wherever Class I or II fans meet the requirement. Design gives unit top efficiency & low noise levels. Wide range of wheel diameters available in both backward & forward curved fans. Chicago Blower Corp.

23 Multiple V-Belt Drives. These modern units for power transmission are discussed from standpoints of origin, history & development in a new 36-page pocket-size booklet from Allis-Chalmers Mfg. Co. Also covers evolution of standards in engineering V-belt drives, how to engineer such a drive, & provides useful data & selection tables.

24 Compressors. Released by Ingersoll-Rand, new bulletin titled "Compressors for the Process Industries." Shows complete range of centrifugal & reciprocating units with electric, steam, gas & diesel power, for all pressures from deep vacuums up to 35,000 lb./sq.in. Capacities to 165,000 cu.ft./min. can be obtained.

25 Speed Reducers. Recent addition of two models to Torque-Arm line of Dodge Mfg. Corp. Now offer shaft-mounted speed reducers with capacities 1 to 60 h.p. & output speeds 12 to 365 rev./min., an increase of 40% in maximum rated horsepower capacity. New sizes have all inherent advantages of other line units.

26 Dust Collectors. The complete line of Torit cabinet cloth filter & cyclone separator type dust collectors is covered in new catalog from Torit Mfg. Co. Literature includes reasons why dust collectors are essential to industry, how unitized collectors can be used & save money. A reference book for plant libraries concerned with collection of noxious dust, lint, chips, powders & fumes.

27 Safety Hats. Lightweight & fabricated from aluminum a line of safety hats from Davis Emergency Equipment Co. Weight & insulation properties of material make hat comfortable & cool in hottest weather. Resists impact in excess of 40 foot-pounds. Will not crack or break if dropped.

28 Vibrator. Called Vibrolator this bantam-size vibrator operates on steam or air. Recently developed by Martin Engineering Co. Weighs only 4 oz. Designed for use on hoppers, feeders, molds, gauge panels, packaging machines, etc. Frequency of vibration from 0 to 50,000 cycles/min. Operating pressures 5 to 150 lb./sq.in.

29 Liquid Chillers. Added to line of Acme Industries, Inc. two complete series of Flow-Therm packaged liquid chillers each with special advantages. Flexibility of units for air conditioning, heat pump & industrial cooling applications emphasized in catalog. Capacities 20 to 175 tons & 15 through 300 tons.

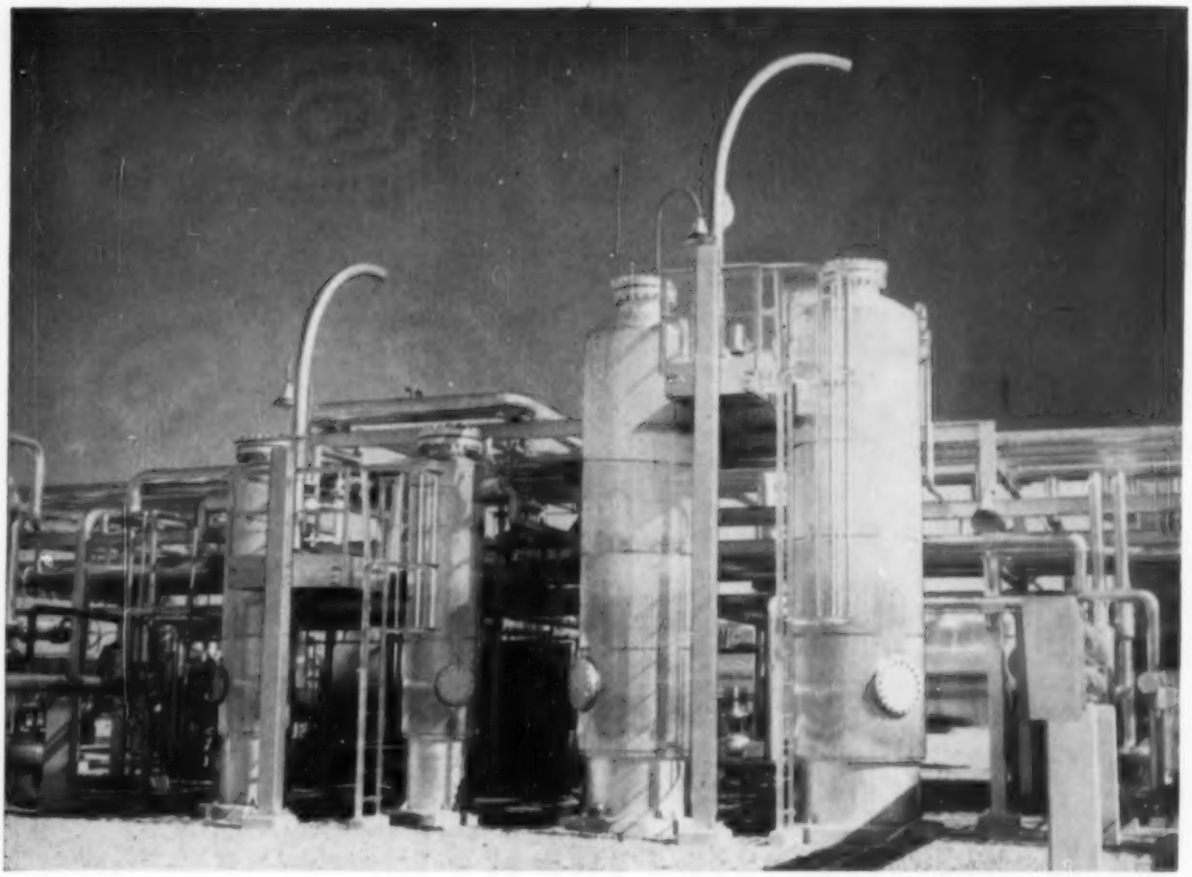
30 Condensation Return Units. From Aurora Pump Div., New York Air Brake Co. announcement of release of bulletin H-113 describing galvanized steel & cast iron receiver condensation return unit. Selection tables & typical dimensions for both types.

31 Gas Indicator. A line of portable instruments designed to meet industrial needs for detecting & measuring flammable gases & vapors introduced by Mine Safety Appliances Co. Four models each intended for specific functions.

32 Mixers. The Cincinnati Hildebrand Co. announces the addition to their line of heavy duty ribbon type mixers suitable for processing mixes of dry powders, crystalline materials, dry colors, etc. Six different agitator designs available. Some for use on end or center discharge of mix, Tee-head units for reduction of lumpy type mixes plus a type for shortening blending.

√ **CHECK** *your Data Service requests on the handy postcard on page 67 to*

▶ **GET** *up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.*



Unibestos makes the big difference in pipe insulation for chemical plants

Not all pipe insulation is alike. There's a difference in insulating capacity . . . in durability . . . in ease of installation. And more and more chemical plants find Unibestos pays off on all three points. For Unibestos is made of Amosite, the long-fiber, quality asbestos that permits single-layer construction with superior insulating properties.

Single-layer Unibestos is easily installed right on the job. It's a strong, long-lasting insulation that withstands vibration and shock . . . resists moisture, steam, acid and chemical fumes. In fact, durable Unibestos is so durable that it can be removed and re-used many times over. Unibestos® pipe insulation is available in sectional form through 44" O.D.

Joe Bestos says:

Write for Free descriptive
Bulletin 109C.

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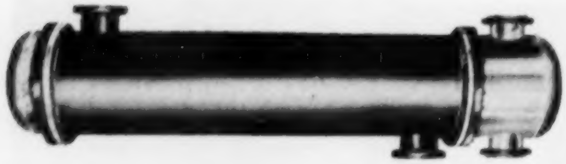
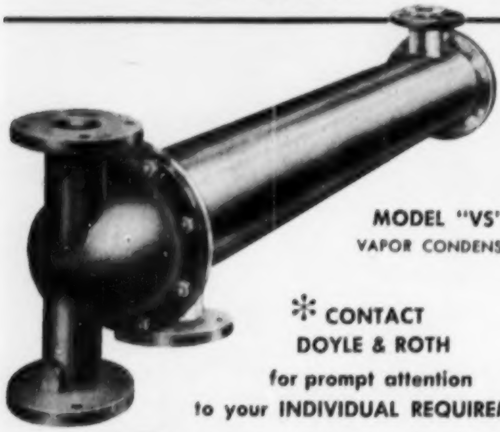
UNION ASBESTOS & RUBBER COMPANY

1111 West Perry Street • Bloomington, Illinois



MODEL "LL"
MULTI-PASS COOLER



MODEL "VS"
VAPOR CONDENSER

MODEL "VT"
VERTICAL
THERMOSYPHON
REBOILER

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DOYLE & ROTH
for prompt attention
to your INDIVIDUAL REQUIREMENTS

Standardized

FOR QUICK DELIVERY!

DOYLE & ROTH
standard stainless steel
HEAT EXCHANGERS

designed . . .

to meet the exacting requirements of the petroleum, chemical and petro-chemical industries.

standardized . . .

to insure lower prices, fast delivery.

D & R passes on to you the economies accruing from its standardization program. Starting with engineering and following through on construction, economies are substantial. Materials are purchased to rigid specifications and standard components are stocked. ASME standards govern fabricating procedures.

DOYLE & ROTH *Manufacturing* CO. INC.
136-50 TWENTY-FOURTH STREET, BROOKLYN 32, N. Y.

PERACETIC ACID

(*Continued from page 64*)

impurities that tended to destroy its value as an epoxidizing agent. Carbide's process produces peracetic directly—that is, in an inert solvent—is anhydrous, and contains no strong acids or salts to catalyze unwanted side reactions during epoxidation except a small amount of acetic acid.

Already, the Carbide peracetic has enlarged the field of possible epoxies, such as styrene oxide, diisobutylene oxide, and 1,4-dichloro-2,3-epoxybutane, none of which could be made commercially until now.

There are many more hitherto noncommercial epoxies that can be made by using pure peracetic acid and which await only the development work of the chemical engineers. Carbide is ready to produce and supply any possible epoxide desired.

The Shockley Semiconductor Laboratory to develop and produce transistors and other semiconductor devices in the field of advanced electronics for automation will be established by Beckman Instruments, Inc., in the community of Stanford, Calif. □

Scheduled to go into production very soon, the new vinyl chloride monomer plant of Solvay Process Division (Allied) at Moundsville, W. Va., will produce high purity vinyl chloride by a process developed jointly with Allied's Nitrogen Division. □

Another step along the path to commercial production of synthetic tree-rubber is this plant being constructed by Goodrich-Gulf Chemicals at Avon Lake, O., scheduled to go on stream later this year. Large truck tires made of Goodrich-Gulf's "tree-rubber" are already giving service and mileage comparable to tires made wholly of natural rubber.

Picture of A CONTINUOUS WAY TO PROCESS HOT* CHEMICALS

* Materials With Temperature Up to 1900° F. Are Being Sucess-fully Handled. Tests Indicate Possibility Of Handling Even Hotter Materials

Here's a way to engineer efficient, continuous-cooling or conveying into your hot material processing.

Sandvik's steel-belt continuous coolers carry the material on a solid, endless, steel band of flat, stainless or carbon steel. This band "floats" on a patented water-bed arrangement which cools from beneath . . . no water gets on top of the band.

You can cool and convey, regulate thickness and graduate temperature while cooling, obtain desired sizes in the same operation, cool and strip off gelatinous materials in sheet form, cool loose and pulverized materials, cool solids in sheet form or crystallize liquids.

A steel belt provides a smooth, hard, impervious surface that is easy to keep clean. It has a high load capacity and a long service life. It can be fitted with simple discharge devices that scrape material off at any point. It can be of any length or width.

Sandvik steel belt units *without* the patented water-bed cooling arrangement can be used for other chemical processing functions such as drying, evaporating, conveying, carrying material through ovens, etc.

ENGINEERING SERVICE—Sandvik's engineering department will be glad to work with you in designing a conveyor to fit your operation. Sandvik has had over thirty years of experience in designing units to operate either as independent units or as integral parts of special processing equipment.

Write, wire or phone for further information.

SANDVIK STEEL BELT CONVEYORS • DIVISION OF SANDVIK STEEL, INC.

1702 Nevins Road, Fair Lawn, N. J.—Tel. Fair Lawn 4-6200

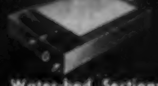
CLEVELAND • CHICAGO • LOS ANGELES

SS-89

SANDVIK STEEL BELT CONVEYORS

PILOT SCALE UNITS AVAILABLE FOR TEST PURPOSES

Experimental units are available to help you determine cooling rates and other data for your specific material.



Water-bed Section-Test Tank

Complete Experimental Water-Bed Belt Cooler

The Technical Man in Community Affairs

W. R. Collings | President, Dow Corning Corporation

As a panel member some time ago in a discussion of "Education for this Industrial Age," I learned that many liberal arts people think that engineers are poorly prepared to play a constructive part in political and cultural affairs.

What I have seen happen in Midland, Michigan, however, shows that if engineers and other scientists are taught to think clearly and are given the opportunity to earn a good salary, they will acquire a true appreciation and understanding of such civic and cultural activities as politics, art, music, and religion as quickly as anyone else.

Background

By 1916, the year I started taking part in Midland affairs, Herbert H. Dow had been working there for about 20 years. I soon learned that he was an active member of the school board, was promoting choral music, and was active in the Presbyterian church. Later he imported an English artist to paint pictures of the Dow plant and the Midland area, and brought in a Japanese landscape architect to help the community make better gardens.

Thus, in addition to being an outstanding inventor, chemist and manager, Dr. Dow had a wide range of other interests, and it is apparent that what our engineers and scientists are doing today in Midland is a result of the primary stimulus that came from him and the men he gathered around him in his early days in Midland.

An incident connected with the founding of the Midland Garden Club is a good example of that stimulus. "H.H." thought there should be such a club working to improve the appearance of Midland and that the way to get it started was to offer substantial cash prizes for good gardens. The Dow Co. and other local business people contributed equally to a fund for that purpose.

Later, when there was to be a Garden Club flower show, "H.H." heard that someone wanted to exhibit individual

CITY COUNCIL—l. to r. around table, N. Poffenberger, physical chemist; F. Olds (hidden), Dow shop supervisor; R. Fry, City Manager; G. Warren, Mayor, organic chemist; C. Supinger, Dow Highway & Construction Lab; and J. W. Stevens, chemical engineer.

MIDLAND SCHOOL BOARD—C. Fink; W. Caldwell, chemical engineer; E. Britton, Supt. of Schools; E. N. Luce, President, chemist; G. J. Williams; Mrs. Sylvia Stoesser, chemist; D. Chapin, chemical engineer; and L. Dankert, organo-chemist.

MIDLAND HOSPITAL—Hospital director Carl Gerstacker with staff member. Chemical engineer Gerstacker is vice president, treasurer and a director of Dow Chemical.

JUNIOR ACHIEVEMENT ADVISORS—T. E. Wilson; H. Bosscher, chemist; B. Harris, chemical engineer; J. Garry, chemist. Standing, C. A. Lankton and J. R. Jackson, chemical engineers.

DOW MALE CHORUS—65 of its 115 members are chemical engineers or chemists.

stalks of gladiolus in milk bottles. "Don't do it," he told club members. "That's a florist's game! Do something different. Never make chemicals or put on flower shows in the conventional way." He suggested instead giving prizes for wild flower arrangements and for miniature gardens in addition to many other ideas. The flower show was, of course, a success, thanks in large part to Dr. Dow's admonition: "Never do anything the conventional way—if it is possible, be different." This admonition, frequently expressed by "H.H.," has come to be an important element in the thinking of those of us who were associated with him.

Another example—when World War I ended, "H.H." suggested that a new court house would be a suitable war memorial—but it should be different. It was built of field stones supplied by Midland County farmers and decorated with murals depicting Midland's early history painted on exterior walls of magnesium oxychloride cement containing another Midland product. In this way he created a feeling of community participation in the very appearance of the building.

A third example is Midland's new library, for which H. H. Dow, the community's first chemical engineer, is responsible. Designed by his son Alden B. Dow, A.I.A., and given to Midland by the Herbert H. and Grace A. Dow Foundation, there is a striking originality here too in the expanse of glass that lights the reading room, the strong horizontal lines accented by oxychloride cement panels, and the functional use of space to provide a cultural center for the community.

With a capacity of 100,000 volumes, the library includes reading rooms, auditorium, lounge and kitchen, young people's room, record library and listening rooms, exhibition hall, local history room, conference rooms, and a children's story-hour amphitheatre.

Another chemical engineer, E. O. Barstow, came to Midland in 1900 as a production manager. But running a plant wasn't enough. He needed other forms of expression and he found them in the Presbyterian Church and in the Community Center he sponsored and built with money he raised. Of course, others helped, but "E.O.B." was the man who put it over. Built in 1919, the old Center's doors were locked on September 11, 1955, and the next morning a new Community Center was opened.

As with the first Center, the second was promoted, financial support was secured without public subscriptions, and the whole project was supervised by Dr. Barstow, now a vice-president of Dow. "E.O.B." had ideas that were different too.

Almost every recreational need is provided for in the new Community Center. There is a gymnasium, indoor swimming pool, conference rooms, mirror room for square dancing and ballet classes, a pioneer room for oldsters, arts and crafts, photography darkrooms, youth center—free juke box and all, snack bar, firearms range, weight room,

(*Continued on page* 84)

BOX SCORE

Participation in Midland community life

Activity	% chemical engineers and chemists
City offices	33
Service club members	50
Service club offices	39
Youth group supervisors	55
School board	71
Theatre Guild offices	56
Dow Male Chorus	56
Presbyterian Church offices	62

JR. CHAMBER OF COMMERCE OFFICERS—A. A. Gunkler, chemical engineer, 1st Vice President; B. B. Hibbard, chemist, International Director; W. Sheets, 2nd Vice President; G. B. Wengert, chemist, Director; W. W. Kennett, chemical engineer, President; and J. E. Pierce, Treasurer.

TRUSTEES OF MEMORIAL PRESBYTERIAN CHURCH—S. Branson; Rev. J. S. Thomas, Asst. Minister; M. L. Bandeen, electrical engineer; H. C. Spencer, biochemist; G. E. Metcalf, mechanical engineer; F. E. Towsley, MS physics; M. A. Key, chemical engineer; R. S. McClurg, chemical engineer; M. S. Putnam, chemical engineer; J. L. Amos, Vice President, chemical engineer; and E. T. Wall, Treasurer.

LITTLE THEATRE GUILD—"Happy Time" rehearsal; D. McLean; H. Malin, chemical engineer; M. Sharp, chemist; P. Reiser, chemical engineer; and Mrs. R. Spencer.

MEMORIAL CHURCH—Dr. C. J. Strosacker, donor of the Bertha Strosacker Memorial Presbyterian Church, took active part in supervising construction.

SCOUTS, TROOP 67—receiving charter. Advisor D. McClurg, chemical engineer; Scout Master K. Nagle, chemical engineer; and President of Paul Bunyan Council R. Prescott, chemist.

designed

engineered

and fabricated

by M&L

The heat transfer and process units shown are only a very few of the many designed and fabricated by Manning & Lewis Engineering Co. every year.

This confidence *must* be warranted:

Our customers have proof, from long association that their heat exchange and process equipment will be:

DESIGNED
. . . for Top Quality Performance

ENGINEERED
. . . for Economy and Efficiency

FABRICATED
. . . with strict adherence to specifications and drawings

These claims are for *US* to prove! Send us your next job for quotation.

We are accustomed to working with all ferrous and non-ferrous metals.

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SALES REPRESENTATIVES IN PRINCIPAL CITIES

THE TECHNICAL MAN

(Continued from page 83)

dining room, handball and squash courts, steam room, and summer day camp facilities for 450 children.

BUILDING THE NEW COMMUNITY CENTER—l. to r., Dave Russell, Center Director; Les Richards; and Alden Dow, the architect.

What the Present-Day Technical People Are Doing

How has such a background affected the younger technologists in Midland today? They are taking part. In this community of 25,000 there are nearly 1,700 technically trained people. About 1,350 of these technical people live inside the city limits, so they comprise 5.5% of the population and carry their share of the responsibility for making the community a good place to live.

Civic Affairs

Since 1916, for over half the time the city government has been headed by a technical man. Four of the last five mayors have been technical people, and the last two have been chemical engineers.

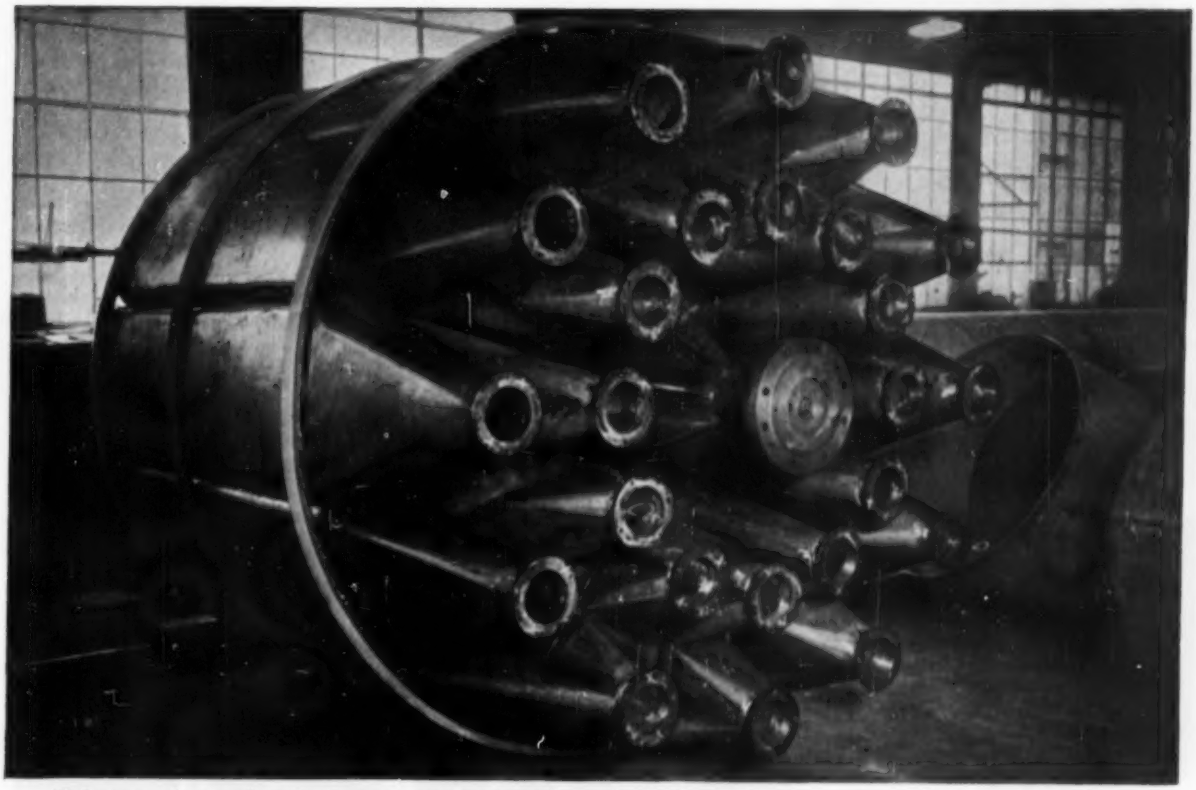
Life in Midland Today

If you live in a town like Midland, there are hundreds of opportunities to serve your community through different organizations and clubs. In Midland there are more than 200. About half the members of Midland's service clubs are technical people. The ratio of technical people to others among the officers in these clubs is about 40%.

YOUTH ACTIVITIES

Youth activities are important to the future of any community. About 55% of the supervisors of such activities in Midland are technical people.

Midland has a birth rate of 33 per 1,000, with the average age of its inhabitants about 25. Twenty elementary schools, two junior high schools and one senior high school work overtime to keep abreast of our educational needs.



Hot magnesium-carbonate slurry presents no corrosion problem when handled by the unit shown here. Made of chromium-nickel stainless steel throughout, this 24-duct indexing hopper for a manufacturer of pipe insulation is an example of all stainless process equipment fabricated by Stainless Products, Inc., Jersey City, N. J.

Chromium-nickel stainless frees hopper from trouble facing many process units

ONE HAZARD that operators face every day is *corrosion.*

As in other processing units, corrosion of an indexing hopper endangers product purity, inflicts expense for maintenance or repair and stops output during the downtime.

But the hopper above, made entirely of chromium-nickel stainless, faces no such trouble. Because ability to thwart attacks by a wide variety of corrosives is a basic characteristic of austenitic chromium-nickel stainless steels.

Helps in other ways, too

In addition, the high mechanical properties of stainless steels allow designers to cut bulk and deadweight without sacrificing strength or safety of process equipment.

Fortified with Nickel, these steels withstand impact and battering, abrasion and erosion. They resist creep and oxidation at elevated temperatures, and retain high strength, toughness and freedom from "notch" effects, to below −400°F.

Easy to clean and keep clean, chromium-nickel stainless steels are sanitary metals that minimize maintenance.

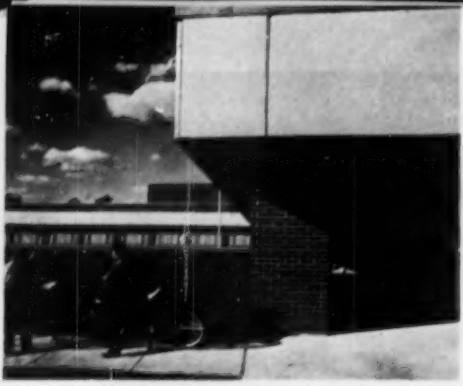
Readily fabricated

Fabricators draw, spin, forge and solder stainless. They punch, shear, bend and weld this versatile material. Leading steel companies produce austenitic chromium-nickel stainless steels in all commercial forms. So investigate use of stainless steel equipment.

Whenever your difficulty is due to metal failure, send us the details. We'll give you suggestions on how to dispose of it. Write for List "A" of available publications. It contains a simple form that makes it easy for you to outline your problem. Send for it now.

Conveying abrasive phenolic powder calls for high resistance to wear. That's why stainless steel is used for this Archimedes conveyor, 50′ long and 14″ in diameter. Screw and housing tube, welded together, rotate as a unit. Design allows easier, faster cleaning, no matter what the color of resin handled. Fabricated by Stainless Products, Inc.

INCO THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N. Y.



NEW COMMUNITY CENTER—70,000 square feet of recreational facilities recently completed at cost of $1,250,000 under leadership of Dr. E. O. Barstow.

▲ **OLD COMMUNITY CENTER**—also built under leadership of Dr. Barstow, was opened in 1919.

COURTHOUSE—built of Midland field stone with walls decorated with local-history murals painted on oxychloride cement. ▼

DOW MEMORIAL LIBRARY—designed by Alden Dow and donated to the community by the Herbert H. and Grace A. Dow Foundation ▼

THE TECHNICAL MAN

(*Continued from page 84*)

On the school board itself, 5 out of 7 offices are held by technical men.

THE CULTURAL SIDE

What about cultural activities? The participation of technical people in the Little Theatre Guild and in the Dow Male Chorus is a good indication of interest and ability in the fields of music and drama.

The Little Theatre Guild, with 170 active participating members, presents four plays a season, running not too far behind Broadway in the presentation of such successes as *My Three Angels, The Grass Harp, Seven Year Itch, Mad Women of Chaillot, O Mistress Mine, Born Yesterday, The Moon is Blue*, and *The Glass Menagerie*. The executive board and committee chairmen of this group number 32, of which 18 are chemical engineers or chemists.

The Dow Male Chorus, founded in 1936, gives several concerts a season plus out-of-town engagements, uniting each year at Christmas with the Dow Girls Chorus and the Dow Symphony Orchestra in an oratorio program. In addition, chamber music groups and the Madrigal Singers, together with well-known solo artists, make Midland's musical life rich and lively. Of the 115 Dow employees who make up the Male Chorus, 65 are chemical engineers or chemists.

◄ **FORESIGHT**—is exemplified in the civic contributions of Dr. E. O. Barstow, left, and Dr. C. J. Strosacker, right.

RELIGIOUS LIFE

In mixing science and religion, the chemical engineers and scientists of Midland also carry their full share of the responsibility. The community has built eight new churches in the past eight years and three more are now building. There are 21 major churches in Midland with an active membership of over 14,000.

An outstanding example of personal devotion is the new Presbyterian church, a gift to the congregation from Dr. C. J. Strosacker, another early associate of H. H. Dow. Dr. Strosacker came to Midland in 1906, and has been responsible for many Dow developments. This church represents more than a gift. Dr. Strosacker put his life into it for several years. He supervised every detail of its design and construction and then presented it complete to the congregation as the Bertha Strosacker Memorial Presbyterian Church in memory of his sister.

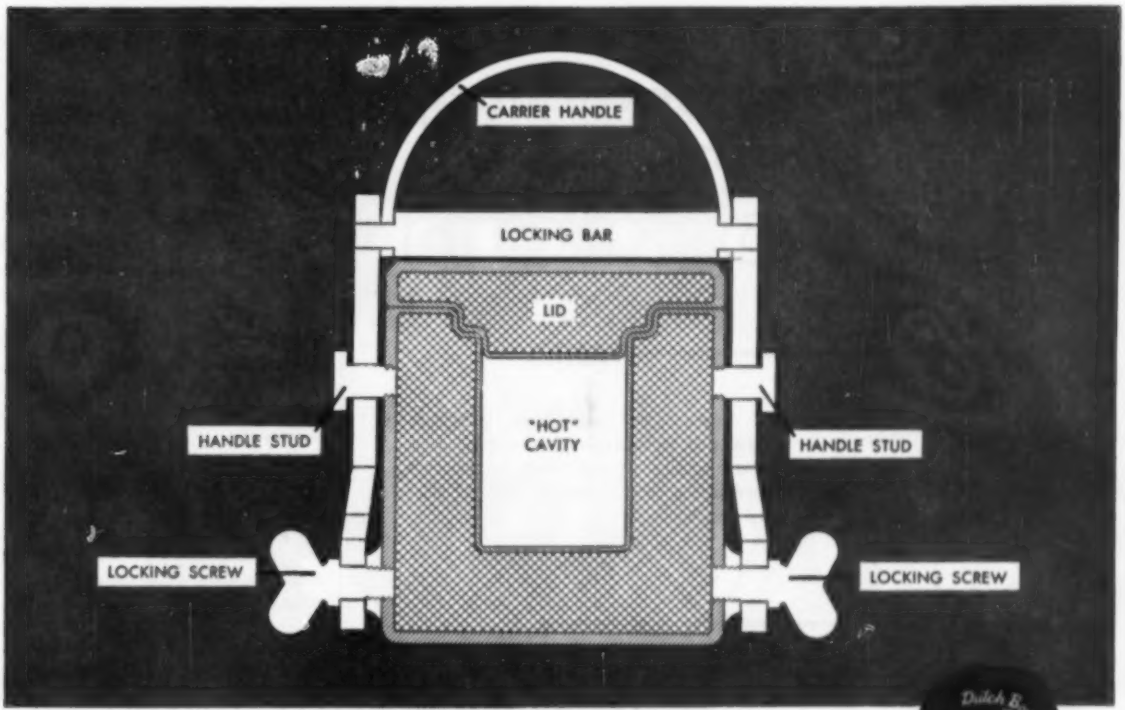
H. H. Dow, above left, founder of The Dow Chemical Company, originated many of the community projects which Midland enjoys today. Dr. W. R. Veazey, Dowell VP, is today active in many of these projects.

About 60% of the deacons, trustees and members of the session of this congregation are chemical engineers or chemists.

It is fitting that this beautiful church, built out of his personal savings and raised in memory of a strong motivating force in one chemical engineer's life work, should provide a spiritual home and religious activity for so many chemical industry scientists.

Conclusion:

These examples demonstrate, more tangibly than any theoretical arguments about the relative merits of an academic or a technical education, the fact that men who have been trained to think clearly and objectively also have the ability to make very substantial contributions to the civic and cultural activities of the community in which they live.



Now! From National Lead...

new, small, containers for *"hot"* shipments

These new National Lead containers, currently produced in four sizes, simplify the shipping and handling of radioactive materials.

The containers are designed to meet ICC-55*** requirements for shipping Group I and II Class D poisons (radioactive materials emitting gamma rays and/or neutrons, alone or with electrically charged corpuscular rays).

Lead-in-steel provides the shielding. Lead thicknesses run from ½" to 2", depending on container size. The stainless steel jacketing keeps the lead where it's needed . . . even if melted accidentally. The handle locking bar, side bars, studs and screws are heavy steel. The stepped closure prevents "beaming."

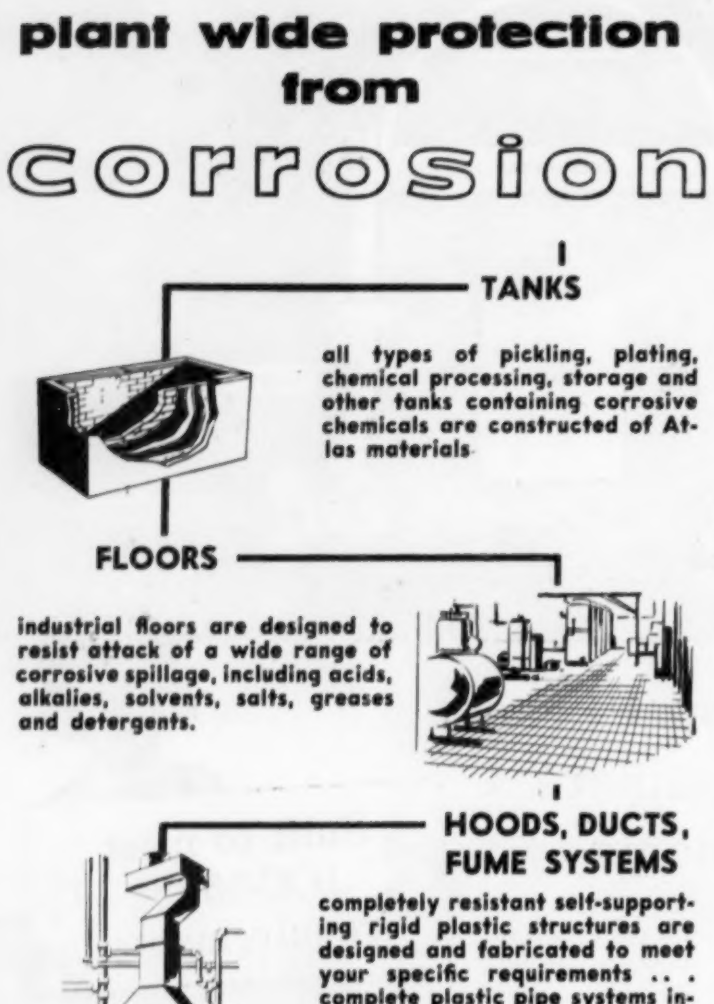
Easy to handle . . . easy to decontaminate.

If you need shipping containers like this . . . or any other type of lead shielding in any shape, size, or tonnage, call on National Lead.

Seals tight. "Lid-loc" handle secures closure against opening from impact, makes for easy handling. Offset closure prevents "beaming."

National Lead Shielding

NATIONAL LEAD COMPANY: New York 6; Atlanta; Baltimore 3; Depew (near Buffalo); Chicago 80; Cincinnati 3; Cleveland 13; Dallas 2; Philadelphia 25; Pittsburgh 12; St. Louis 1; Boston 6 (National Lead Co. of Mass.); Los Angeles 23 (Morris P. Kirk & Son, Inc.); Toronto, Canada (Canada Metal Co., Ltd.).



CHEMICO TO LEAVE CYANAMID—FORMICA COMES TO CYANAMID

Major shift in the chemical construction field is announced.

Negotiations for the transfer of Chemical Construction Corporation, a major company in the chemical construction field, from Cyanamid to Electric Bond and Share are now nearing completion.

At the same time, Cyanamid has purchased the business and assets of the Formica Co., leading producer of plastic laminates.

Chemico will continue to render design, engineering and construction services to Cyanamid and other clients in the process industries as an independent but integral part of the Electric Bond and Share organization. The company, which has engineered and installed some 30% of the world's ammonia capacity, and some 33% of the world's sulfuric acid capacity, will have its services strengthened and expanded, particularly in the field of organic chemicals where it has extensive experience already.

The association between Chemico and Electric Bond's present construction subsidiary, Ebasco Services, is expected to be highly beneficial to both companies, since the talents and experience of both organizations will be available to each other.

Cyanamid will form its own engineering and construction division, headed by Gen. A. C. McAuliffe, which will carry on with the company's engineering projects.

With the acquisition of Formica, now known as Formica Corp., Cyanamid's broad research programs will be joined with Formica's extensive marketing organization, and increased production is expected. A joint product-development committee of Cyanamid and Formica is already exploring new product possibilities.

A multi-million dollar plant for processing shortening and edible oils will be built in the Montreal area this year by Procter & Gamble of Canada. □

Expansion of Monsanto's phthalic anhydride facilities at Everett, Mass., will provide a 60% increase in the plant's output. Plant will be on-stream early in 1957. □

Synthetic glycerine production capacity will be substantially increased at Dow's Velasco, Tex., plant which is already producing some 36 million pounds/year. □

When you consider

COST

also consider

PERFORMANCE

BE SURE—in your estimate of drying equipment costs—TO INCLUDE:

UNIFORMITY OF PRODUCT
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LONGER EQUIPMENT LIFE
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HIGHER PRODUCTIVITY
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MANUFACTURER'S SERVICE TO YOU
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LOW MAINTENANCE COSTS

Proctor is your best investment when you consider these factors in the selection of drying equipment.

Hundreds of successful installations of Proctor Equipment give proof of these extra performance values.

You'll profit by specifying Proctor.

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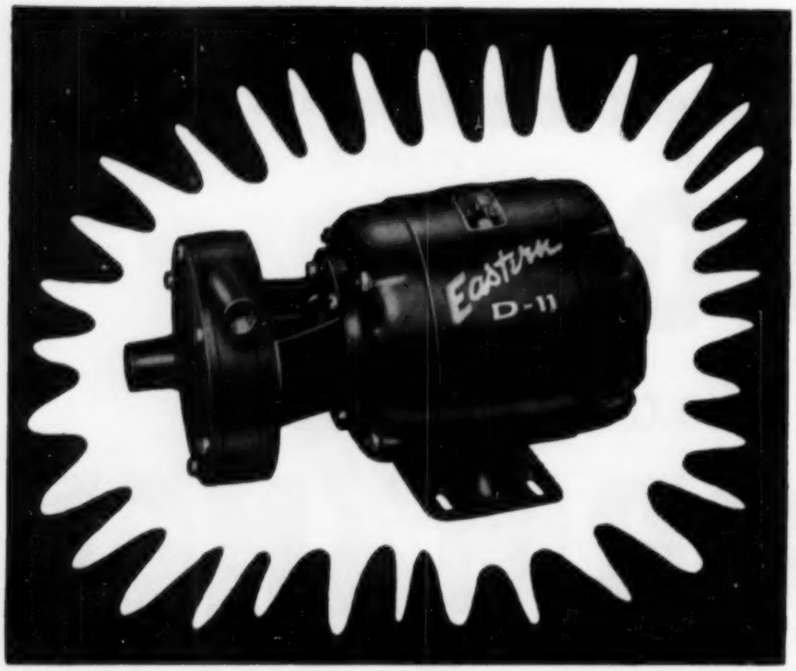
Manufacturers of Industrial Drying Equipment and Textile Machinery.



24,830 successful installations!

EASTERN D-11 CENTRIFUGAL PUMP

Why is the D-11 so successful among original equipment manufacturers? *Size and weight* make it ideal. The D-11 is the smallest, close-coupled, single-stage centrifugal pump available with an induction type motor. Eighteen pounds of compact design (9¾" x 4⅝") make it excel in industrial and process equipment, as well as laboratory service, and pilot plant operations.

SPECIAL METALS

A full selection of metals make the D-11 and other Eastern Centrifugal Pumps versatile performers. Available in 18-8 Type 303 and Type 316 Stainless Steel, Monel, Hastelloy "C", Cast Iron and Bronze, Eastern Pumps range from ⅛th to ¾ H.P. with capacities up to 70 G.P.M., pressures to 65 P.S.I.

For complete specifications on all Eastern Centrifugal Pumps, request Bulletin 120-A

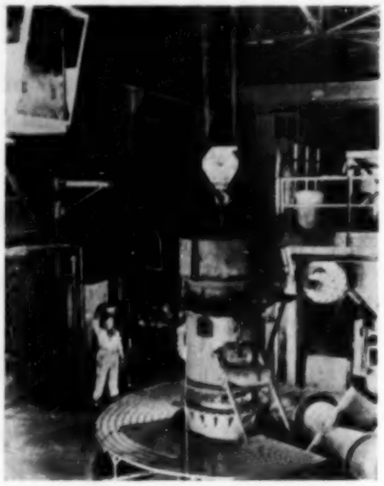
Eastern INDUSTRIES, INC.
100 Skiff St., Hamden 14, Conn.

INDUSTRIAL NEWS

Two contact sulfuric plants will be built by Chemical Construction Corp. The first, a 100-ton/day plant for Kennecott Copper at Hayden, Ariz., will be designed and equipped by Chemico, built by Western-Knapp Engineering. Raw material for the Arizona plant will be roaster gas from roasting operations.

The second plant will be designed, equipped and constructed by Chemico for Shawinigan Chemicals, Canada. A 75-ton/day plant, it will be located at Shawinigan Falls, Quebec. □

Annual production of Hercules' new pentaerythritol plant at Louisiana, Mo., will be 24 million pounds of pentaerythritol and 100 million pounds of formaldehyde, a basic PE raw material, when work already underway is completed and the plant opens in early 1957. □



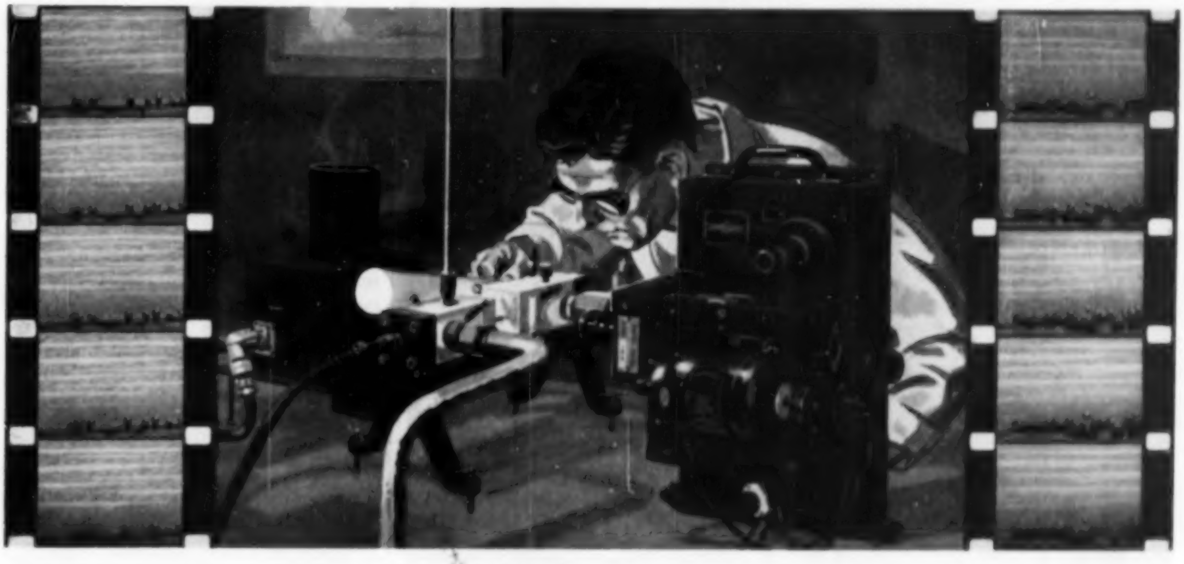
Output of Titanium Metals Corp. of America's Henderson, Nevada, plant will be increased from 3600 to 6000 tons/year when new facilities come on-stream in late 1956. The new production capacity is being constructed without Government contractual guarantees. In the picture, ore is being charged into the chlorinator, an early step in the process.

The latest type of air pollution control equipment will be built into Wyandotte Chemical's $2.5 million expansion of its cement plant facilities. □

A 40,000-ton butadiene plant will be the first unit built by Firestone Tire on a recently purchased 1000-acre site designed for petrochemical production. The site, near Orange, Tex., is ideally located for raw materials. Design and construction of the plant will be done by Catalytic Construction. □

Notable Achievements at JPL

***HIGH SPEED PHOTOGRAPHS OF NUCLEATE BOILING** were first taken at JPL using a special camera fitted with a Kerr cell shutter. Sequence photos, taken at speeds up to 20,000 frames per second, were the first series of high-speed, high-resolution motion pictures to successfully stop the action of nucleate boiling.*



Pioneers in Rocket Motor Heat Transfer Research

JPL JOB OPPORTUNITIES ARE WAITING FOR YOU TODAY
in these fields

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- NUCLEAR PHYSICS
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- SOLID STATE PHYSICS
- CHEMICAL ENGINEERING
- HEAT TRANSFER
- COMBUSTION
- MECHANICAL ENGINEERING
- NUCLEAR ENGINEERING

As a result of knowledge gained from the high speed photos and from subsequent work, the role of bubble dynamics has been incorporated into theories of nucleate boiling heat transfer which is the principal mode of heat transfer encountered in the regenerative cooling of liquid propellant rocket motors.

Because of the very high temperatures encountered in propellant combustion, JPL has been engaged in a broad program studying various modes of heat transfer. Emphasis has been placed on studies of boiling heat transfer to liquids, turbulent boundary layer heat transfer to deLaval nozzles, nonsteady heat transfer due to oscillatory flow, and heat transfer with chemical reaction in the boundary layer and on the surface.

The influence of chemical effects is one of several programs that has benefited from the association of talents and experimental techniques from several different fields of specialization. The broad and varied programs, ranging from laboratory experiments to responsibility for missile flight testing, have created unique working conditions for our technical personnel.

Here, at JPL, the research engineer enjoys, to an unusual degree, the stimulus of practical application coupled with an academic atmosphere. If you are interested in such problems and working conditions, we would like to hear from you.

CALTECH jpl JET PROPULSION LABORATORY
A DIVISION OF CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

Up she goes!...at Sinclair's new UDEX Plant built by Badger Manufacturing Company.

42-ton stripper...by Downingtown

Diameter: 6′ I.D. • Total Height: 133′ 3″ • Shell Thickness: ¾″
Material: Carbon Steel • Total Weight: 42 tons • 40 Bubble Cap Trays

Fabricated at DOWNINGTOWN IRON WORKS for Badger Manufacturing Company. Stress relieved...spot X-rayed...Code stamped. Field erected by Badger Manufacturing Company at UDEX Plant of Sinclair Refining Company, Marcus Hook, Pa. Send for Bulletin PF and learn more about Downingtown engineering experience and fabricating skill.

Downingtown Iron Works, Inc.

HEAT EXCHANGERS—STEEL AND ALLOY PLATE FABRICATION

151 Wallace Ave., Downingtown, Pennsylvania—Branch Offices:

1458 S. 66th St., Milwaukee 14 • 52 Vanderbilt Ave., Room 2032, New York 17 • 271 Hanna Bldg., Cleveland 15 • 936 W. Peachtree St., N.W., Room 144, Atlanta 3 • 208 S. LaSalle St., Room 765, Chicago 4 • 586 Roosevelt Bldg., Los Angeles 17 • 4550 Main St., Room 234, Kansas City 6, Mo. • 106 Wallace Ave., Downingtown, Pa.

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

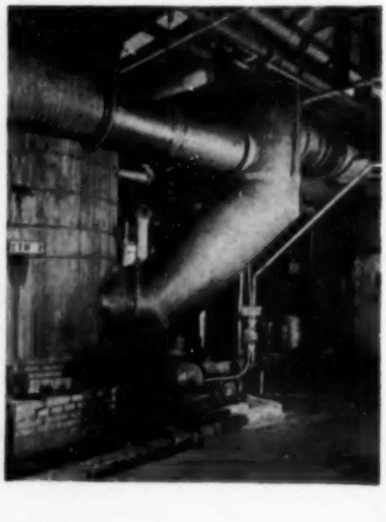
Under a new licensing agreement, 40,000 tons per year of butadiene for synthetic rubber will be produced with a Houdry dehydrogenation unit by Firestone Tire and Rubber. Engineering and construction of the unit will be handled by Catalytic Construction Company, is already well along in the engineering phase, completion of the unit, located at Orange, Tex., is scheduled for early 1957. □

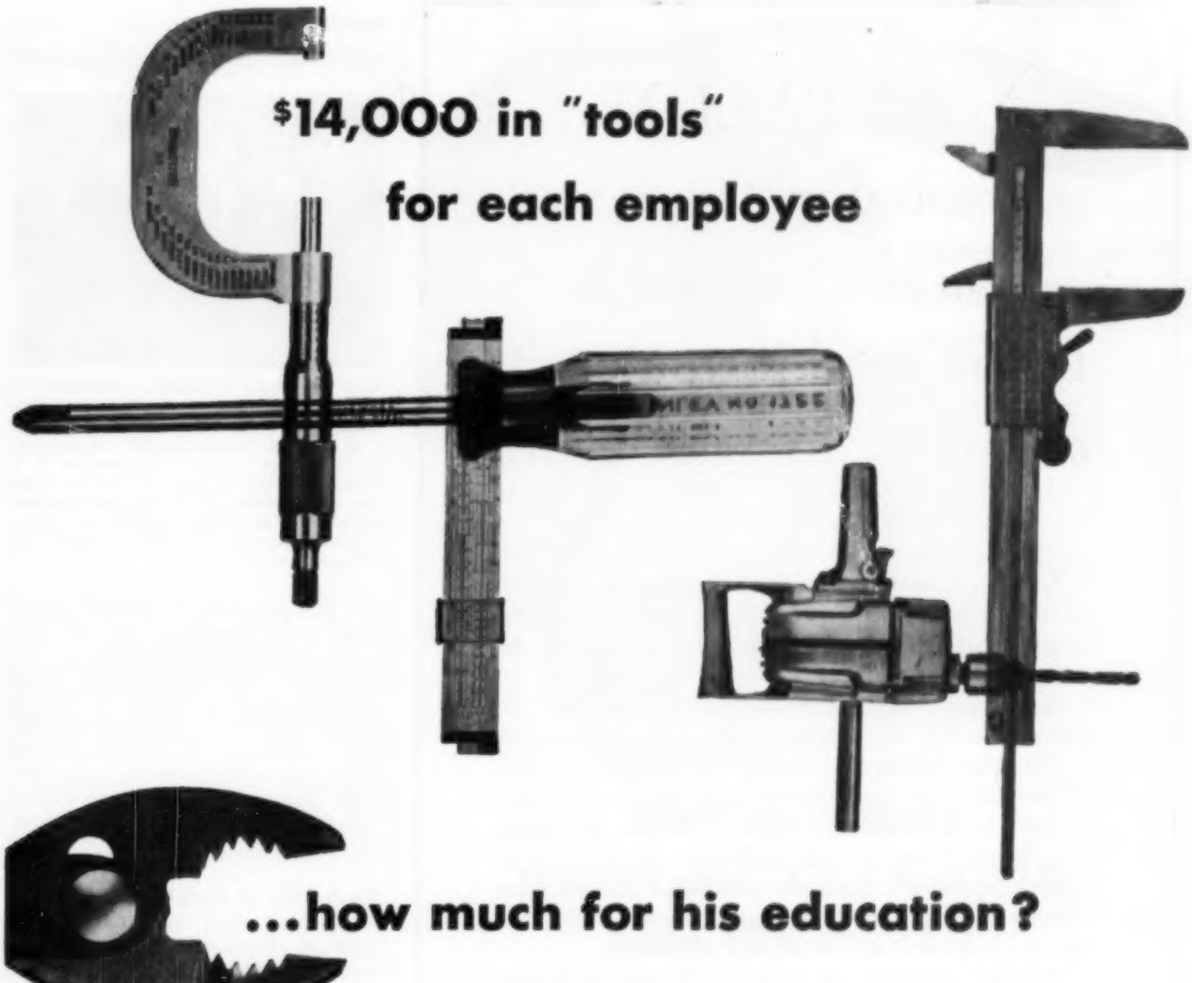
Long term corporate planning, and evaluation of new business opportunities, will be important objectives of Union Carbide's new division, the Union Carbide Development Co. □

A new nylon emulsion bonding, coating and finishing agent, already proven suitable for the textile, paper and rubber industries, has just gone into production by Belding Corticelli Industries, Inc. Manufactured from type 8 nylon resin under license from Du Pont, the new product is identified as BCI Nylon Dispersion. □

The major expansion of Northern Chemical Industries at Searsport, Maine, is now nearing completion. Major plant is a new 100 ton/day sulfuric acid contact plant. Engineering is being done by Girdler, construction by the Leonard Construction Co. □

The service life for tanks, hoods and exhaust ducts and fans used in chemical processing has been extended many times by Fiberglas-reinforced plastic systems engineered by du Verre, Inc., Buffalo, N. Y. The large venting ducts shown above are Fiberglas-polyester, were installed by du Verre in a chemical plant, are still in good condition after three years. Corrosion-resistant metals formerly used here had a service life counted in weeks, according to Owens-Corning Fiberglas Corp., producer of Fiberglas.





Today, business invests an average of $14,000 in each employee's job. The question for businessmen is: Are we training enough people who can hold down these jobs? Schools are the answer. And it's simple self interest to help community groups get the teachers and equipment schools need. Shortage right now: 200,000 classrooms, 165,000 teachers!

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Want to find out how to help in *your* community?
Get specific information by writing:
Better Schools, 9 East 40th Street, New York, N. Y.

TANTALUM...
If you don't need it, you can't afford it. If you need it, you can't afford to do without it!

It is an easy matter to determine whether or not you need tantalum in your process. If tantalum eliminates shut-down, product contamination, side reactions, fume damage and other waste due to corrosion, *you need it!*

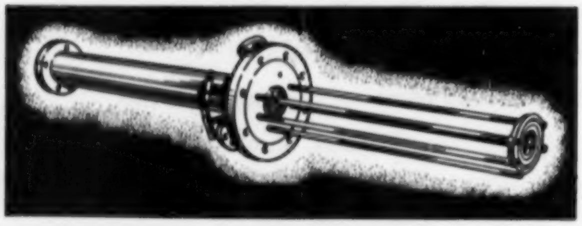
If tantalum increases equipment life four-fold, or more, even if it costs only twice as much...you need it!

Tantalum is immune (not merely resistant) to any of the following: hydrochloric acid, nitric acid, perchloric acid, bromine, iodine, hydrogen peroxide, chlorine, chlorine dioxide and many others. It is so slowly attacked by sulfuric acid that life may be measured in decades. It is strong, immune to thermal shock, unequalled in heat transfer efficiency.

Fansteel engineers can evaluate the pros and cons of tantalum very precisely as they apply to your process. From that point, it will be very easy for you to reach your own conclusions.

USE TANTALUM WITH ECONOMY for most acid solutions and corrosive gases or vapors.

Not recommended for HF, strong alkalis or substances containing free SO_3.



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FANSTEEL METALLURGICAL CORPORATION
Chemical Equipment Division
NORTH CHICAGO, ILLINOIS, U.S.A.

G562A

Tenth anniversary of Catalytic Construction Co. was the occasion for a special luncheon where congratulations were in order. Attending were, (l. to r.) C. H. Thayer, Sun Oil vice president, W. G. Jamison, Catalytic vice president, T. E. Webster, Catalytic president, A. T. Knight, Catalytic vice president, C. G. Kirkbride, president of Houdry Process Corp. of which Catalytic is a subsidiary, and C. C. Peavy, Houdry vice president.

The first overseas shipment of an unusual resin, Dapon, has just been made by Food Machinery and Chemical. The resin is a solid prepolymer of diallyl phthalate, used currently in molding powders which exhibit striking electrical properties. The shipment just made was a trial shipment to an electrical varnish manufacturer in France. The resin is now available in commercial quantities. ☐

Production of perchloroethylene will be doubled when the expansion program at Diamond Alkali's Houston plant is completed early in 1957. ☐

Announced expansion of its methanol and petrochemical derivatives facilities will cost Commercial Solvents $10 million. ☐

Increased space for application research on diisocyanates is the reason for National Aniline Division (Allied) expanding its Buffalo Research-Engineering Center with a new building. ☐

A new machine to clad lead to steel has been patented by American Viscose and Knapp Mills. The machine creates a homogeneous bond between steel and lead, is expected to find great use in the nuclear field. ☐

A Conference on Mathematics in Engineering will be held at the University of Michigan on June 20-22. Tentative schedule includes sessions on: Probability, Statistics, Numerical Analysis and Computers, Operations Research and Systems Engineering, Continuum Mechanics and Field Theory, and the Impact of Mathematics on Engineering and Scientific Education.

Approval has been given by the Boards of Directors of Foote Mineral and of Electro Manganese Corp. for Foote to absorb Electro Manganese on virtually a share for share basis. ☐

Plastics are now making a strong showing in total production with some 3.6 billion pounds per year, an estimated 10 billion pounds per year by 1975, according to J. F. Sayre, manager of marketing for Allied's Barrett Division. ☐

With the manpower shortage growing, the chemical industries are turning to women for the first time since World War II. Despite the many supposed drawbacks of female employees, the industry is beginning to realize that women have many advantages for industrial use, such as patience, manipulative skill, and color perception. ☐

A radio news program for engineers! Designed to keep technical personnel abreast of events in all phases of engineering, the five-minute program "News For Engineers" over Station KFI in Southern California is sponsored by Beckman Instruments. ☐

Modernization of the huge Institute, W. Va., synthetic rubber plant, recently sold to Goodrich-Gulf Chemicals for $11 million, will take about four years. ☐

Finding oil is the goal of the new Freeport Oil Co. formed as a division of Freeport Sulphur Co. Freeport is already producing 5,200 bbls./day. ☐

An intensive program in infra-red spectroscopy will be given August 6 to 17 at MIT. It will consist of two integrated one-week courses. ☐

The Sixth International Symposium on Combustion will be held at Yale University, August 19-24. This is the first symposium under the auspices of the new permanent organization, The Combustion Institute, and promises to be of extreme interest and importance. ☐

An ultra-long infra-red cell and spectrometer is being constructed by The Franklin Institute Laboratories for Research and Development to be used for studies of air pollution and smog in the Los Angeles area. The unit will be housed in a special mobile laboratory. ☐

Metallized papers will soon be in production by Foiltone Products, a wholly-owned subsidiary of National Research Corp. The company is already marketing metallized plastics. ☐

CURTISS-WRIGHT

DYNAMIC CAPACITOR ELECTROMETER

FOR STABLE AMPLIFICATION OF LOW-LEVEL DC SIGNALS

Measures currents as low as 10^{-14} amp. • Extremely high input impedance . . . 10^{18} ohms. • Low drift — less than ± 1 mv per 24 hours. • Uses dependable, durable dynamic capacitor. • Accuracy of ± ½ % full scale. • Only 14" x 10" x 9"

The Curtiss-Wright Dynamic Capacitor Electrometer is ideal for measuring minute currents or voltages from high impedance sources. There is no 60 cps interference since the Dynamic Capacitor Electrometer operates at 1,000 cps. The instrument can be used to measure static charges, potentials of floating grids, insulation leakage currents, capacitor dielectric leakages; and to study transistors and diodes. Its ruggedness, reliability, and high sensitivity make it especially suited for use in the nuclear field as a component in reactor control systems and in industrial control systems employing radioisotopes as energy sources. It can be used for pH determination, and in mass spectrometry. In biophysics and medicine it may be used to measure cell potentials, skin potentials, streaming potentials, injury potentials, and nerve impulses. Besides providing an indication on its own meter, it will operate any standard recorder. For details, write Nuclear Equipment Sales Dept., Curtiss-Wright Corporation, Electronics Division, Carlstadt, N. J.

ELECTRONICS DIVISION
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modern centrifuges for continuous chemical processing

SKIG nozzle centrifuges used where one liquid containing solids is to be clarified or to concentrate solids in a relatively small portion of liquid. The "Jet-O-Matic" has continuous clarification, unique recycling system, large diameter nozzles and pressure discharge by centripetal pump.

Is your field chemical, pharmaceutical, food processing, fuel oils? Westfalia's complete line of continuous clarifiers and separators offer the solution to your problem with superior time, labor, and money-saving equipment. Westfalia's *continuous* centrifuges handle: Liquid-solid clarification; liquid-liquid-solid separation; liquid-liquid counter-current solvent extraction; and concentration of solids.

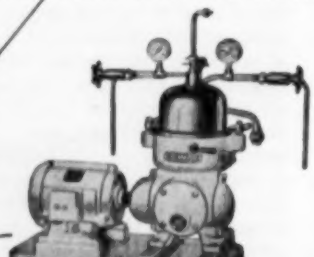
SKOOG-10006

SAOH-4006

SKOOG "Jet-O-Matic" recycle oil separator. Largest available nozzle-type. Constant recycle. Sectioned hood. Easy cleaning. Applications: Immiscible liquids. Vegetable and animal oils.

SAOH "Liquid-SEAL" automatic de-sludger. Continous centrifuge with automatic sludge discharge. Stainless steel at all contact points. Available with built-in single or double centripetal discharge pump. Can be used as separator, clarifier, or extractor.

LG "Liquid-SEAL" pilot plant centrifuge. Triple purpose machine. Serves as separator, clarifier, or extractor. Has ruggedness, efficiency of larger equipment. All 316 stainless steel. Double centripetal discharge pump. Applications: Laboratory, pilot plant and small scale production.



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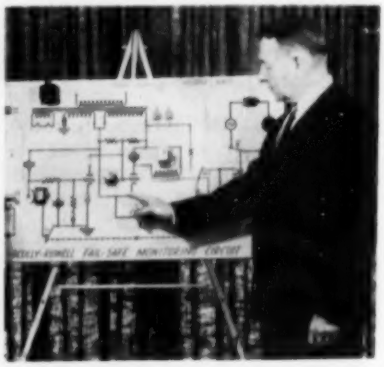
INDUSTRIAL NEWS

Production of an additional 65 million pounds of ethylene glycol per year is in the works for Carbide & Carbon's Seadrift, Tex., ethylene oxide facilities. Total capacity for ethylene oxide at this one plant will now be 200 million pounds/year. □

Three new units, to manufacture acetylene, ammonia and methanol, will be built at Rohm & Haas' Houston plant. To be engineered and constructed by Chemical Construction Co., the acetylene unit will use the BASF (Sachsse) process. The ammonia and methanol units will be built by Foster Wheeler. □

Expansion and modernization of Du Pont's coated fabrics plant at Newburgh, N. Y., began early in March, will cost more than $3 million. □



Employing a revolutionary self-checking principle, the new Scully-Rowell fail-safe monitoring circuit is applicable to a multitude of automation techniques now in use in industry, to industrial heating systems, to atomic energy systems, and to such special applications as aircraft safety systems.

A new multi-million-dollar low-pressure linear-type polyethylene plant will be built in Woodbridge Township, N. J., by Koppers. Construction is already underway, will be completed in early 1957 for production of some 30 million pounds/year.

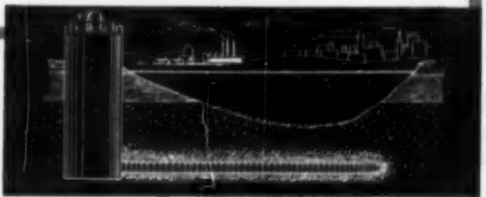
A second giant low-pressure polyethylene plant will be built by Koppers and Brea Chemicals in Los Angeles county. Larger, this plant will produce some 60 million pounds, will cost $10 million, is expected to be in operation in mid 1957. □

Devoted entirely to research, engineering, development, sales and administration, the new Administrative and Engineering Center of Vickers, Inc., is located in Detroit. □

NOW a RANNEY METHOD for every WATER NEED...

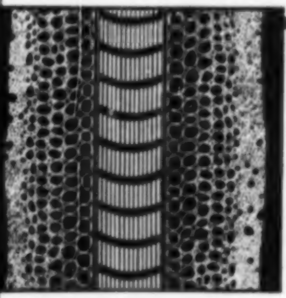
the CONVENTIONAL Ranney Collector

Proven by countless installations around the world, the collector yields naturally filtered water with less equipment, less personnel, and fewer pumps than other conventional systems.



the Ranney INFILTRATION GALLERY

Engineered by Ranney to provide low cost water supply to industry and community. The Gallery provides large quantities of clear non-turbid water in a revolutionary yet economical way. The Gallery requires no maintenance.



the Ranney VERTUBE well

Developed exclusively for low volume users. It provides a natural gravel vertical water well at low cost. The Ranney Vertube is engineered with the same precision and efficiency as its two bigger brothers.

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AMONG THE MANY RANNEY USERS ARE: Industries: Granite City Steel Co., U. S. Steel Corp., Eli Lilly and Co., Shell Oil Co., Monsanto Chemical Co., E. I. duPont de Nemours and Co., Timken Roller Bearing Co. Cities: Boise, Idaho, Canton, O., Parkersburg, W. Va., Manitowoc, Wis. Write to Dept. CE-5.

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American Agile...first introduced the spraying and forming of structural shapes from Polyethylene . . . first to commercially weld Plastics and first to commercially introduce irradiated Polyethylene molded parts.

It will pay you to check with American Agile whenever you need fabrications or components that give you these advantages:

- Long Service Life
- High Impact Strength
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- Chemically Inert to 170°F.

The polyethylene scrubber illustrated above, the largest ever made of this material, is another example of Agile's engineering. This unit is 5 ft. high, 4 ft. in diameter, with a gas flow of 2500 cfm at 1½" p.s.i. It is being used in contact with hydrofluoric acid and fluorides with concentration under 60%.

Send in your blueprints for a quotation or write for complete details..Ask for bulletin AA-2.

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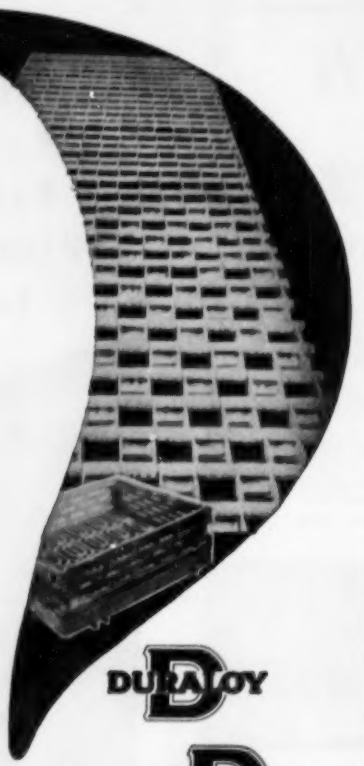

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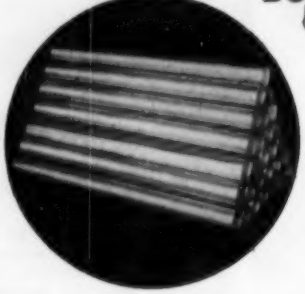
Corrosion Resistant

Abrasion Resistant



When ready to order, how about checking with us here at DURALOY? For more than thirty years we have specialized in high-alloy castings. In fact, we were among the first to produce static castings and the first to produce centrifugal castings. We are old hands at producing castings alloyed to fit each specific requirement and to finish them to any extent desired.

Melt, castings and finishing are carefully controlled and quality tested by our staff of metallurgists, chemists, X-ray and gamma ray technicians. If you would like more preliminary information, send for Bulletin No. 3150-G.

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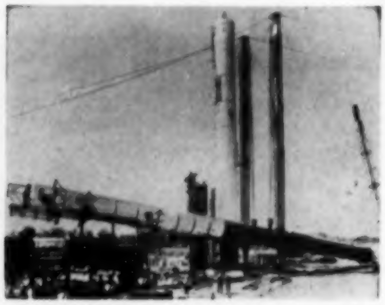
KING-SIZE FRACTIONATING TOWER

186-foot fractionating tower is built, shipped and erected in one piece by Delta Tank.

One of the largest fractionating towers ever built (as high as a 20-story building) has just been constructed and shipped as a single unit by Delta Tank Manufacturing Co.'s Baton Rouge, La., plant.

Eight feet in diameter, and weighing 293,000 pounds, the carbon steel column is one of two built for American Cyanamid's new mono-methylstyrene plant at Avondale, La., and is nearly double the height of standard fractionating columns.



The column is raised into place at Cyanamid's new Avondale, La., mono-methylstyrene plant.

Shipment as a single, completed tower insures equipment quality and reduces erection and finishing costs, but involves a major problem of stress relieving in the shop. Delta accomplished the task by using its new jet-fired furnace at Baton Rouge, stress relieving in three "heats." A third of the tower was stress relieved at a time in the 1300° F. furnace—a task that required several days.

Just completed, the new polyvinyl acetate polymer plant of National Starch products at Meredosia, Ill., will now have its capacity doubled. Engineering, procurement and construction is being handled by Blaw-Knox. □

As part of its continuing expansion and modernization program, Selas Corporation of America, developer, designer and manufacturer of microporous filters, membrane type separators, heaters and other fluid process equipment for the chemical, petroleum, petrochemical and plastics industries, has just moved into its new plant and headquarters in Dresher, Pa., a northern suburb of Philadelphia. All research and development, manufacturing and sales are now located in the one installation. The move was necessitated by the rapid expansion of Selas' business. □

The expanded facilities of Wayne University's Computation Laboratory will be available for the University's famous summer program dealing with electronic computers and their industrial and business applications. Nationally-known speakers will be present, and among the new facilities is an IBM 650 computer. □

A combined liberal arts-engineering program is to be offered by DePaul Univ. in cooperation with Illinois Tech. in an effort to help alleviate the nation's shortage of engineers.

A five-year program, the plan will result in the student's earning two degrees, a BA from De Paul and a BS in Engineering from Illinois Tech. Normally this would take six years. □

The demand for chemical, petrochemical and oil-field equipment has forced Delta Tank Manufacturing Co. to convert its Baton Rouge plant from defense to civil production, and the company's withdrawal from defense contracts. □

The pipe in this picture is corrosion resistant wrought iron. Installed in the ground in 1918, the pipe has carried crude oil without benefit of cathodic protection ever since. Dug up recently, it was found in such good condition it has been cleaned and is ready to go back to work. Maker A. M. Byers of Pittsburgh is rightfully proud of its pipe.

Continuous furnace for curing tape resistors has been designed at the National Bureau of Standards. Using a liquid heat exchange medium to achieve highly stable temperature control, the curing temperature can be held to plus or minus 1° C. on long-term operations. □

Seven European companies have been licensed by Girdler to use the Elastomer process in the production of vinyl foam. Of the seven licensees, two are French, three are English, one is Swedish, and one German. □

A new plant to produce xanthate for Canada's growing mining industry will be built at North American Cyanamid's Welland plant at Port Robinson, Ont. Xanthate is a reagent widely used in the flotation process of ore concentration. The plant is expected to be ready by the end of 1956. □

AEC CONTRACT SETS OFF MAJOR ZIRCONIUM PRODUCTION BOOM —WILL OPEN LARGE SUPPLY FOR INDUSTRY

A five-year contract to supply AEC's reactor needs for zirconium brings U.S. Industrial Chemicals and National Research Corp. into zirconium field, means large expansion of Carborundum Co.'s facilities. Three large-scale plants to be built, both U.S.I. and NRC have new processes.

Sharp price-cut for zirconium already results.

Wide non-reactor applications seen for the versatile, highly corrosion-resistant metal, particularly in the fabrication of process equipment.

The importance of zirconium metal in atomic power-reactor construction has led AEC to contract with U.S.I., NRC & Carborundum for 2,200,000 lbs./yr. over a five-year period. This major development will have a strong effect on the nuclear and chemical industries. Already the price of zirconium has dropped. NRC's price to AEC is $6.50/lb., and U.S.I.'s is indicated by company officials to be under $5/lb.

All three companies will build new plants, both U.S.I. and NRC have new processes. All indications are that the AEC requirements are only the beginning of an accelerating zirconium expansion aimed, largely, at wide non-reactor uses of the corrosion-resistant metal.

Largest share of the new contract goes to U.S.I., a division of National Distillers. New in the field, U.S.I. will deliver 1 million pounds per year of reactor grade zirconium to AEC. NRC, through its Metals Corp., is also new in the field and will deliver 700,000 pounds per year. Carborundum, already producing 325,000 pounds per year for AEC, will now expand by an additional 500,000 pounds per year.

Zirconium's importance as a structural metal in reactors comes from its extremely low neutron capture or absorption, its high resistance to heat and corrosion, and its adaptability to maintenance and repair. These same properties make the metal equally valuable in process equipment, except, of course, for the low nuclear capture. To achieve zirconium of a grade suitable for reactors, it must be separated from hafnium, a metal almost identical but having a high neutron capture. Since hafnium always occurs with zirconium in nature, a costly separation step is involved. But for commercial non-reactor applications the hafnium does not have to be removed, lowering the cost of the metal still further for non-reactor applications.

Non-Reactor Potential

Entry of two major chemical companies into the zirconium field, both with new processes, is indication of strong growth potential expectation. All three new plants are being built for capacities larger than AEC's requirements.

Richard S. Morse, left, is president, and Robert A. Stauffer, right, is vice-president of National Research Corporation and its wholly-owned subsidiary, NRC Metals Corporation. The company's experience in rare metals production enabled its technicians to develop a process that reduces prime production cost of zirconium by 50% and resulted in a $22,750,000 supply contract with the AEC.

U.S.I.'s at Ashtabula, O., will produce 1.5 million pounds per year, will be geared for quick expansion, will be on-stream in mid-1957. Carborundum's plant at Parkersburg, W. Va., will also bring the company's total capacity to 1.5 million pounds per year, will be on stream early in 1957. NRC's Pensacola, Fla., plant has also been designed to produce in excess of AEC's requirements.

That this additional production is aimed at non-reactor markets, primarily in the chemical process industries, is no secret as far as the companies are concerned. U.S.I., which has a semi-works plant under construction to produce 2000 lbs./day of zirconium while the full plant is being built, will concentrate this small unit entirely on non-reactor grade material as soon as the plant is freed of more pressing commitments.

High Corrosion Resistance

Industry has long been aware of the potential applications of zirconium, mainly based on its extremely high corrosion resistance (it has been used in Europe for spinerets in rayon production), but the price has been high ($14 a pound more or less) and the supply limited. With AEC's new contract providing a firm base for the new companies in the field, and with the new processes, supply is expected to rise abruptly and the price may well drop to as low as $3.50 per pound for non-reactor grade, according to U.S.I. NRC is convinced that the non-reactor market will ultimately exceed Government requirements.

Main industrial advantage of zirconium is its extreme resistance to corrosion. It is equally resistant to caustic soda and hydrochloric acid. At the same time it is a strong, ductile, easily machineable metal, and is expected to find its main application in the fabrication of process equipment. Particularly favorable from an industrial viewpoint is the abundance of zirconium's major ore, zircon. It is found in the sands of Florida and Oregon, and its world-wide abundance exceeds that of nickel, copper, lead, zinc, and other familiar corrosion resistant metals.

Zirconium has an affinity for gases that makes it valuable in radio tubes and fluorescent lamps. It may have a wide application as a cleanser in metallurgical processes, particularly as a desulfurizing and deoxidizing agent for steel. Its future as an alloying material is bright. It imparts desirable properties to magnesium, adding strength when in high proportion and workability in small proportion. It gives the hardest gold-base alloy known. As zirconium boride it can withstand temperatures up to 6000° F.

Potentially, zirconium's uses are legion, and the companies feel that when the cost drops a little lower it will be competitive with other, better-known anti-corrosion metals for specific applications.

New Processes

Carborundum will use the now established Kroll process, which is based on reduction with magnesium. But U.S.I. and NRC have come up with new processes. Neither company is talking details as yet, but U.S.I. has indicated the nature of its innovations.

At the heart of U.S.I.'s process is a sodium reduction step instead of a magnesium. This change has resulted, according to the company, in a considerable number of advantages.

First, the U.S.I. process is semi-continuous rather than batch as is the Kroll process. Much work has been done to make the Kroll or other processes continuous but without too much success as yet. And the electrolytic processes still have many bugs in them to be ironed out before they can hope to become commercial.

Second, a more uniform product is produced, the melt being essentially homogeneous. In fact U.S.I. hopes that the AEC will simplify its now complicated sampling requirements since the U.S.I. product is far more uniform than the Kroll on which the sampling techniques are based.

According to U.S.I., the zirconium sponge can be turned out much faster by the new process. Therefore, a smaller unit is required, with far less initial investment than the Kroll—about one-third, the company estimates. Since the reduction step is one of the two most expensive parts of the whole refining process (the other is the hafnium separation), the lower price for U.S.I.'s product is to be expected.

In U.S.I.'s process, however, the hafnium separation step is the same as that used in the Bureau of Mines process. U.S.I.'s versatile reduction process is not limited to zirconium, but can be used to produce titanium, thorium, beryllium, and hafnium as well. The company is ready to license the process under certain conditions.

NRC's process is strictly under wraps at the moment. The company's plant, located conveniently near the raw material source in Florida, is also located next to the new Escambia Bay petrochemical installation, of which NRC is part owner, and nitric acid and ammonia from Escambia are essential components of the company's new refining process.

Important Potential

With nuclear energy installations expanding rapidly, particularly now that industrial reactors are more and more in the wind, the market for zirconium is growing. As the price drops, the companies involved expect non-reactor uses to become more important. U.S.I. is already predicting an expected price on finished zirconium parts for the chemical industry of $15 a pound. When its semi-works plant in Ashtabula is completed U.S.I. plans to work on the strictly industrial problem of reclaiming the hitherto unreclaimable scrap zirconium from fabricating operations.

Certainly the reactor application of the metal will hold the major importance for some time, but with the new plants and processes, process applications will now have a good opportunity to be evaluated.

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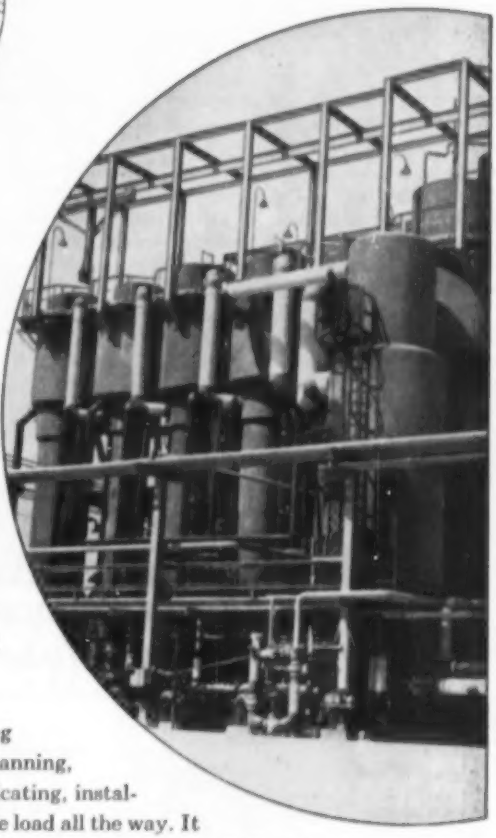

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PRESIDENT EISENHOWER CREATES NATIONAL COMMITTEE FOR DEVELOPMENT OF SCIENTISTS AND ENGINEERS

Main job of new Committee is to "foster the development of more highly qualified technical manpower."

With recent reports in hand indicating that the Soviet Union already has more engineers and scientists than the U.S.A., is graduating new ones at a rate more than twice our own each year, the need for some official body to study and work on the engineering and science manpower situation is clear.

By appointing the new board, named the National Committee for the Development of Scientists and Engineers, the President recognized the responsibility of the Government in this matter of needed technological personnel, but stressed that the basic responsibility lies in the concerted actions of all citizens, and citizens groups, particularly those intimately connected with the problem, such as the engineering societies.

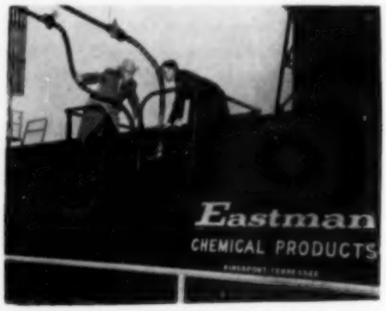
Heading up the Committee is H. L. Bevis, president of Ohio State Univ., and assisting him is E. A. Walker, dean of the College of Engineering and Architecture at Penn State. Engineering's representatives are T. H. Chilton and Maynard Boring, and the Committee has on it men from science, education, management, labor, state and local government, and the humanities.

In the President's view the purposes of the new Committee are: to assist the Government in identifying the problems actually involved; to enlist the cooperation of individuals and organizations, and to coordinate them outside the Government; to make all possible information available to those who are concerned with overcoming the problem; to stimulate public interest and support by publicizing the problem; and to report on progress to the President.

There is little question as to the magnitude of the problem of the shortage of technical manpower. Perhaps it has been put best by A. T. Waterman, director of The National Science Foundation which is responsible for providing staff services for the Committee and for leading other departments and agencies in carrying forward activities which will help solve the problem, when he said, "At every turn, there is evidence of America's increasing dependence on science and technology for its cultural, economic and defensive strength. . . . It is obvious that this strength depends on high-level education for more of our people . . . we cannot sustain our economic and defensive strength without a strong and healthy science as well as technology . . . the growth of (our) corps of scientists and engineers accounts for our world position in technology."

Manufacturing capacity for both "Amanol," nitrogen solutions used for fertilizer, and anhydrous ammonia, will be increased at North American Cyanamid, Ltd.'s Welland, Ontario, plant. □

Upwards of $35 million will be spent by Gulf Oil on new installations for its Philadelphia refinery. The improvements will not substantially increase total refinery production, already the largest on the East Coast, but will greatly improve the quality, and will make the refinery one of the best equipped in the world. □



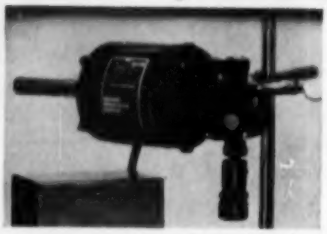
Traditionally shipped in drums, which presented too many problems to be considered economical, Tenamene 2, a phenylene diamine type gasoline gum inhibitor, can now be shipped in tank cars with a new shipping system developed by Eastman Chemical Products, a subsidiary of Eastman Kodak.

Probably the largest anhydrous alcohol unit ever built has just gone on stream at U. S. Industrial Chemical's Tuscola, Ill., plant. □

Cycolac, a new type of thermoplastic, will be the product at the new Marbon Chemical plant to be built by Catalytic Construction, cost $10 million. Demand has been so high for the high-impact resin that Marbon, a Borg-Warner division, cannot supply enough from its two present plants. □

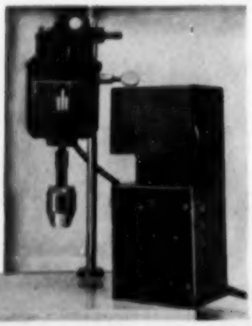
One of the first moves in an over-all expansion program by Columbian Carbon is the construction of a new office-laboratory building in Akron. Columbian assumed the sale of its own products last July 1, hence the expansion. □

ELECTRONIC CONTROLLED
LABORATORY STIRRER
WITH SPECIAL BODINE MOTOR
and Thyratron Tube Control



Direct and gear drive in one fully enclosed ball bearing motor. Variable Speed at full torque. 1/50 H.P. motor. Can be run in either direction.

The speed on direct drive ranges from 400 rpm to 5000 rpm in stepless control. The speed of gear-driven shaft is 1/18 the direct or armature speed.



Starting torque on armature is 32 in ounces. May also be used to drive constant speed devices. Stirrer can be attached to ordinary laboratory support stand.

STIRRER—Motor is driven by a phase shift Thyratron Tube controlled rectifier, which converts the alternating current of the mains to direct current. Field and armature of motor are fed separately by two—2050 gas rectifier tubes. **Price $88.00**

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This watermelon-shaped rubber tank, developed by Goodyear, could revolutionize the bulk transportation and storage of fuels and other liquids. Called the Rolli-Tanker, the container can be rolled over ground, even rocky terrain, can be floated in water and dropped without bursting. It is designed to meet the needs of process industry manufacturers, builders, farmers, the armed forces, and anyone faced with liquid handling problems.

More than $1.5 million will be spent by Alco Products on expansion of its Beaumont, Texas, plant, the former Beaumont Iron Works Co. □

The new polyethylene plant of Koppers at Port Arthur, Tex., went on stream recently, is rated at 18 million pounds/year. In full commercial production, the new plant is largely of the "outdoor" type. □

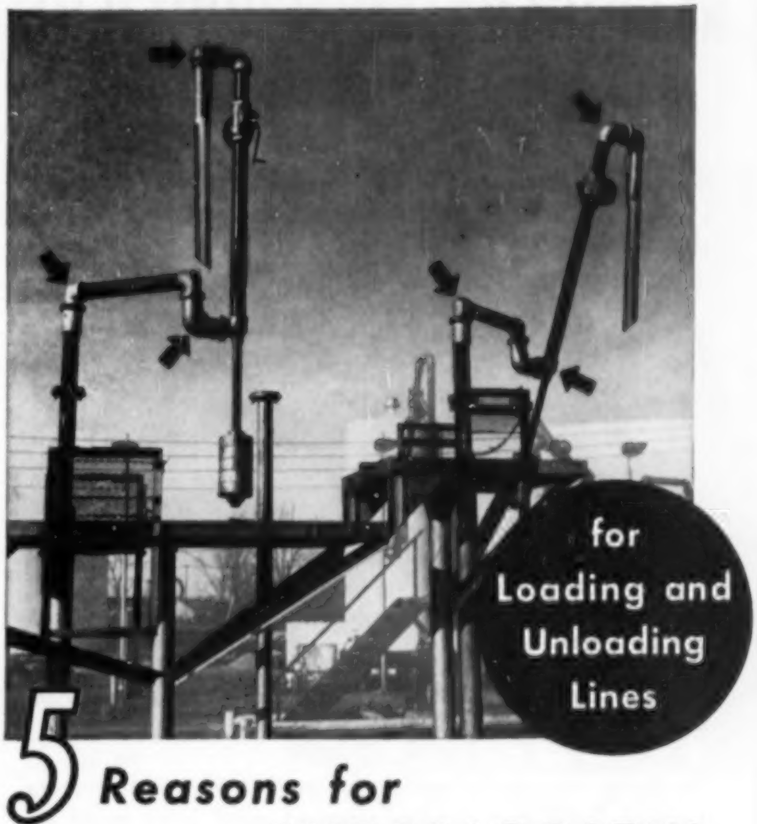
Barge harbor facilities will be built by Dravo Corp. for Olin Mathieson's new giant aluminum plant near Clarington, O. (See p. 63 this issue.) □

Witco Chemical has sold its oil and gas producing properties. Fifteen of the company's 25 oil and gas wells were sold to Producing Properties, Inc., Dallas, Tex., for some $1,750,000. □

A leading producer of soluble silicates, Philadelphia Quartz Co., is celebrating its 125th anniversary this year. □

The lubricating properties of Moly-Sulfide lubricant additive are graphically attested to in this picture of a conventionally lubricated chassis bushing (r.) after 35,000 miles in service, contrasted to a bushing lubricated with grease containing 3% Moly-Sulfide after 160,000 miles service. The Moly-Sulfide will film out on the bearing surface under particularly heavy stresses where the grease film is removed.

BARCO Swing Joints and Assemblies



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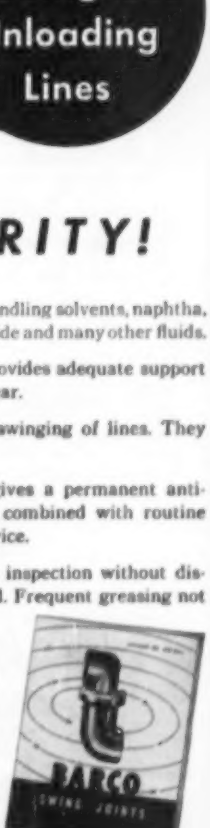
4. **LONG LIFE**—New "Bar-Moly" dry lubricant process gives a permanent anti-galling, corrosive-resistant finish to moving parts. This, combined with routine lubrication, insures longest possible maintenance-free service.
5. **EASY MAINTENANCE**—Joints can be disassembled for inspection without disconnecting piping. O-rings are easily renewable in the field. Frequent greasing not required to maintain sealing.

The Barco line is complete with single swing, double swing, and counter-balance styles and assemblies to meet every need. Sizes 1", 1½", 2", 2½", 3", 4". All steel or malleable iron. Send for latest Catalog No. 400 containing engineering and ordering information. *Worldwide sales and service.*



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We design and build Liquifiers for hydrofluoric acid recovery in monel, nickel steel or other required metal, using direct expansion of refrigerant, usually Freon-12, 22 or Freon-13. Also Liquifiers for chlorine in steel, often using A-300 material to get the required Charpy Impact values at low temperatures.

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A versatile data handling system for the chemical and process industries marks Beckman Instruments' entry into the data logging field. Speed and versatility characterize the system, with easy digital control and an analog-to-digital converter to perform the mathematical functions necessary to transform the electrical measurements into numerical form.

A new unit will double the production of Elvanol polyvinyl alcohol at Du Pont's Niagara Falls, N. Y., plant. □

The largest expansion program in the history of the American-Marietta Co., totalling $15 million, will include expansion of facilities at several Standard Lime and Cement Co. plants, where production of lime, dolomite and magnesite will be increased to keep pace with the steel, chemical, and construction industries. A new production unit will increase the capacity of the Southern Cement Co. division by 60% at Roberta, Ala. □

In the planning stage is a new $10 million plastics plant for Borg-Warner. To be located at Washington, W. Va., the new plant is the company's Marbon Chemical Division's answer to a "market exceeding highest expectations," for its new-type thermoplastic resin Cycolac. □

Anhydrous ammonia will be produced at the rate of 100,000 tons/year at the planned new $12.5 million petrochemical plant of Petroleum Chemicals, Inc., a jointly owned company of Cities Service and Continental Oil. Already in construction, the new plant will get its hydrogen from the refineries of its parent companies at Lake Charles, La., where the plant is to be located. □

Construction is underway on W. R. Grace's new major polyethylene plant at Baton Rouge, La. Producing the new temperature-resistant polyethylene, under license from Phillips Petroleum, the installation will consist of a $1 million semi-works plant for polyethylene and other polymers, expected to go into operation this summer, and a large commercial plant for polyethylene which is expected to be on-stream by mid-1957.

The planned new 7 million gal./year methanol plant of Hercules Powder will use the Swiss Inventa process for the first time in this country to produce methanol. The plant will cost in excess of $2 million, a large part of its methanol production will be used in the company's adjacent new pentaerythritol plant. □

A new plastic laminate, with properties particularly suited for automatic production of electronic equipment utilizing printed circuits, has recently been put on the market by the Laminated & Insulating Products Department of General Electric. A brochure is available on request from the division's offices in Coshocton, O. □

Rowe Paint & Varnish Co. has changed its name to Rowe Products, Inc., since the old name no longer described the company's custom-made formulations in protective coatings for chemical environments. □

An Industrial Chemicals Division has just been created by Pittsburgh Coke & Chemical. The new division, a consolidation of the former Coal Chemicals and Plasticizer Divisions, in addition to carrying on the production and sales of the former divisions, will include an expanded Product Development Section for the development and promotion of new industrial products. □

Establishment of a Refractories Division as a new operating unit of Corning Glass Works will consolidate the development, manufacture and sale of the company's conventional refractories, high temperature refractories, and Corning Glascast Mold material for precision casting of metal alloys. □

A new company, Whitman Laboratories, Inc., has been formed to manufacture and sell chemicals and food products, initially concentrating its activities in the industrial chemical field. □

One of the two sulfur recovery reaction furnaces for Tide Water's new refinery near Delaware City, Delaware, this unit is the largest single piece of equipment in size and weight ever manufactured by the Bigelow Co. The unit was designed by Ralph M. Parsons Co. for C. F. Braun and Co. Tide Water's new plant will have a capacity of 130,000 bbls./day, is said to be the largest industrial site ever acquired on the eastern seaboard.

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Sargent builds these dryers with any number of trays; single or multiple stacked; one or more deep; for highly varied drying speeds and material loads.

The dryer above, for example, is installed in a cotton-seed oil processing plant. Another SARGENT design, for wet powdered and unstable materials, has 40 trays, 10 high, double stacked, 2 trays deep. The entire interior of this dryer-evaporator (including trays, fan, housing, inlet vanes, baffles, exhaust ports, etc.) is of a special type stainless steel. Air splitters and baffles distribute an even air flow across every tray. Guaranteed performance: a minimum of 100 lbs. water removed from a 200 lb. charge in 8 hours at 60° C.

SARGENT dryers are designed with product protection paramount. Every dryer, every new product, is "proven out" in Sargent's own expertly staffed Drying Research Laboratory, for *your* protection. Unusually rugged construction, economy and dependable guaranteed performance are Sargent standards.

There's a SARGENT dryer to do the job for the process industries **— conveyor or tray; pole or tunnel; stationary or rotary. High speed or low, heavy capacity or light; continuous or batch methods. All Sargent-designed for the specific job. For more details, write**

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The attainment in recent years of high combustion rates in advanced types of engine led to the decision to attempt similar advances in a burner of the industrial type which has proved advantageous.

INDUSTRIAL BURNER designed on basis of FAST REACTIONS THEORY

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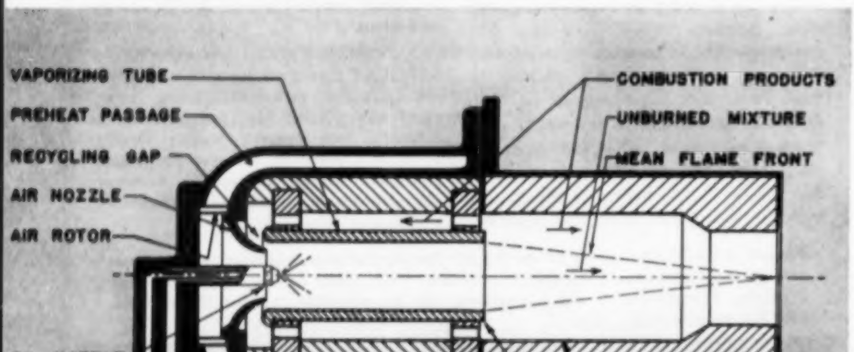
It is probable that the application of the burning of fuels to the production of power for propulsive purposes has been mainly responsible for awakening real interest in the combustion process. First with the internal-combustion reciprocating engine and then much more markedly with the rotating and nonrotating jet engines, the continual pressure for greater output per unit of engine weight or size has resulted in great advances in combustion techniques in terms of heat released per unit volume. This can readily be seen from the space-heating rate of stationary equipment, such as various types of furnaces and boilers, where values in the range of 50,000 to 100,000 B.t.u./(cu. ft.)(hr.) at atmospheric pressure are common, as compared with turbojet and ramjet combustors, where values of 5 to 10 million are achieved on the same basis.

The recognition of such gains in one field naturally led to the question of the feasibility and desirability of similar advances in combustion technique in other forms of equipment such as industrial heating and processing apparatus. The desirability point appeared to be answered by the possibility of reducing burner size itself and, more importantly, by the possible reduction of size of the associated equipment in which the heat is to be used. This latter possibility arises from the fact that high-output combustors inherently produce high-velocity gas streams, and heat transfer equipment can often be made more compact by taking advantage of these rapid flows.

Fig. 1. Cross section of oil burner.



The burner, or combustor, configuration which will be discussed was developed with this thought in mind. Although it is of interest in that its principal features are somewhat different from other high-output combustion units, the discussion will in particular show how available knowledge was utilized in arriving at the design, what the results have been, and what some of the unexplained behavior aspects of the burner indicate is still to be learned. In the last decade or so the study of the fundamental processes involved in practical combustion systems has been greatly intensified; it is felt that the present problem is a typical case where some of the resulting information has been used successfully and where at the same time problem areas remain where engineers do not know how to translate the results of the research worker back to the practical design problem. A situation of this type can be found in any field of technology, but it is perhaps more acute in the combustion field than in most others.

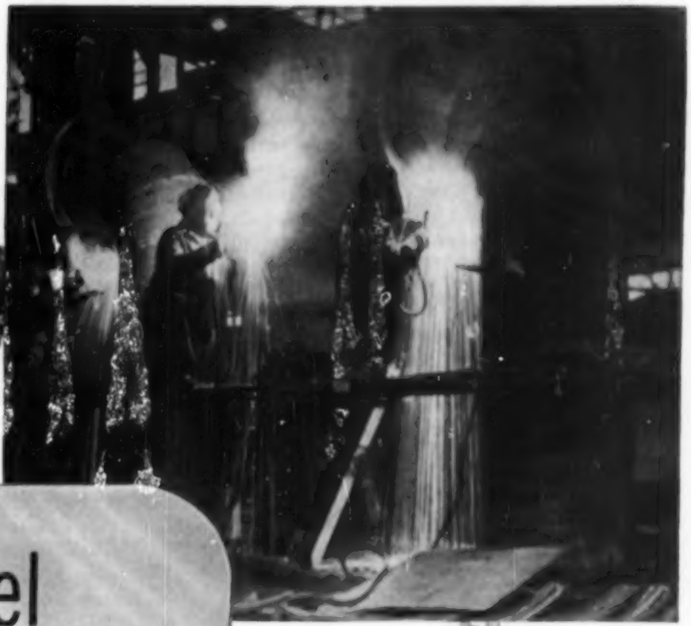
Combustion Process

Three steps into which the combustion process can be separated are mixture preparation, ignition, and burning.

It has been known for some time that burning can be achieved efficiently in a given volume if sufficient turbulence is present. If the model of a turbulent flame as a highly wrinkled or convoluted burning surface (of small but finite thickness) is accepted, it leads naturally to the conclusion that such conditions increase the reaction volume within any given over-all volume, or that what might be termed the *reaction density* of a reactor volume is raised. Beyond providing the requisite turbulence, with proper mixture preparation and ignition assumed, there is little more to be done to increase burning rates other than to alter the physical or chemical characteristics of the mixture in a manner which will increase its normal burning velocity. Therefore, it is possible to accept the burning step as straightforward, as long as a high throughput of properly prepared and ignited mixture is fed to the burning zone.

The ignition step requires that sufficient energy be imparted to each element of mixture to initiate a self-sustaining reaction. This energy may come from the reaction zone of the already existing flame or may be provided by some separate source. Except for initial starting of a system, the reaction zone is depended upon almost exclusively in most designs. But it is also

(Continued on page 108)



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INDUSTRIAL BURNER DESIGNED ON BASIS OF FAST REACTIONS THEORY

(Continued from page 106)

known that a given mixture under given conditions of turbulence exhibits a definite burning velocity. Therefore, if flow velocities exceed this value, the flame will blow off or out of the burner. Since such a situation will exist in a burner designed for the output rates desired, it was recognized that some form of flame holding or piloting would be required. It was known that bluff bodies and shapes of different types, when placed in a flowing stream of mixture, have a stabilizing or flame-holding effect, and this method was selected, in the form of a step or setback in the duct wall.

Proper mixture preparation is the step which, from the viewpoint of practical equipment, necessitated the most careful consideration. To a first order of approximation it may be assumed

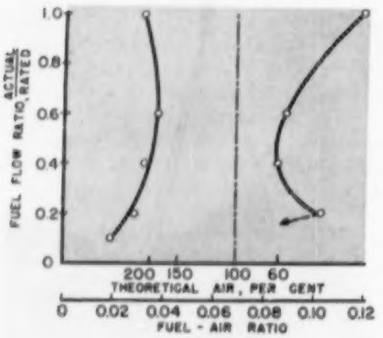

Fig. 2. Burner stability limits.

that the ideal situation requires a physically and chemically homogeneous mixture throughout the entire stream. This is not too difficult to obtain, at least to a reasonable degree, when a gaseous fuel is mixed with air, although even in this case the requirement of high throughput can introduce a number of problems. But in the case of liquid fuels, to which attention was directed in this development, the problem is somewhat more complicated by the addition of the steps of atomization and vaporization of the fuel. In the majority of liquid-fuel burners these processes take place largely within the combustion space; in this case, the objective was retained of trying to deliver a prepared mixture to the combustion chamber. This would obviously require the addition of heat from some source to give any fairly complete degree of fuel vaporization. It was decided to take this heat from the combustion-chamber section of the burner by recycling a portion of the hot gases back into the upstream end of the burner. With the properties of the fuel, which was to be of the distillate type, or so-called "No. 2 fuel," known, it was possible to calculate the amount of heat required and to design the recycling arrangement accordingly.

Burner Design

Figure 1 shows the resulting configuration. To the right of the flange is the combustion chamber, consisting of a refractory-lined stainless steel shell. The left-hand section of the assembly consists basically of two concentric cylindrical shells, providing space for distribution of the combustion air between them. The inner shell is refractory lined; two refractory baffle rings are embedded in this lining and support a central tube, also of a refractory ceramic. The rings are pierced with a circular row of small holes, giving access to the annular space around the central tube. A metal air nozzle is attached to the back plate of the outer shell and mates with a recess on the end of the inner shell. It is spaced away from the back plate by a stationary air rotor of the squirrel-cage type, the function of which is to impart a spinning motion to the air. The fuel nozzle is mounted on the axis in the convergent section of the air nozzle. Fuel nozzles of the return line or spill type have been chosen for this work, as they permit variation of output with less change in spray characteristics than is true with fixed-area nozzles.

The principle of operation is as follows. When air is admitted through the nozzle, the pressure relationships at either end of the central, or vaporizing, tube are such that flow occurs from the combustion chamber back through the annular space, mixing with the incoming air stream as it leaves the nozzle. When burning is taking place in the chamber, this recycling flow is sufficiently hot to maintain the vaporizing tube at high temperature. Thus the fuel is sprayed into a rapidly moving air stream, and, as it moves through the hot zone, it is vaporized and mixed. In this way a properly prepared mixture is delivered to the combustion zone. The step formed by the end of the vaporizing tube and the downstream baffle ring acts as a flame holder, and burning proceeds from the perimeter toward the axis of the flowing mixture.

The determination of the relative proportions in this configuration has been discussed quantitatively by Johnson and Eustis (*1*), and so only the principles will be outlined here. With 1 lb./sq.in. gauge chosen as a practicable combustion air-supply pressure, the air nozzle was designed to provide a static pressure at its outlet just slightly above the burner exit static pressure. The velocity thus obtained, in the neighborhood of 265 ft./sec., assisted in the atomization of the oil spray and also provided sufficient velocity to prevent the flame from moving upstream into the vaporizing tube. The length of the vaporizing tube was determined by computing the time necessary for the mean-size droplet of fuel to vaporize. Here the rotation of the air stream helps by carrying the larger particles out into actual contact with the wall of the vaporizing tube. The diameter of this tube was proportioned to allow the desired amount of recycling flow, as well as maintenance of adequate velocity to prevent flashback. If a temperature of 500° F. is required in the unburned mixture leaving the tube in order for fuel vaporization to be complete, the recirculating flow needed represents about 15% of the total air flow.

The combustion chamber can be varied considerably in size and shape, depending on what is desired. Burners of this type have been fired directly into large-volume furnaces, although the flow pattern in such cases usually leads to somewhat cooler gases returning in the recycling zone, with attendant decrease in the quality of operation. Normally the chamber is proportioned so that combustion is reasonably complete when the gases leave the exit port. A representative figure is that 75 to 80% of the theoretical temperature rise is achieved at this point. Gas analyses at the same point show compatible combustion completion values. The use of nozzle, or exit, chokes on the combustion chamber has been determined by the velocity desired in the particular application. For a design of the type shown in Figure 1, exit-gas velocities would be in the 300 to 500 ft./sec. range. Exit nozzles also tend to increase burner stability in some instances.

Performance

Measurements of the output of this burner, in terms of heat release or space-heating rate, have been made by taking the product of fuel rate, higher heating value, and temperature-rise ratio (actual vs. theoretical temperature) and dividing this by the combustion-chamber volume. Values of 10 million B.t.u./(cu. ft.)(hr.)(atm.) have been obtained in this manner. It should be pointed out that use of the higher heating value is artificial, but in accord with practice in rating industrial combustion equipment. It may also be somewhat arbitrary to consider only the combustion-chamber volume itself in comparing with designs where additional volume is included for reasons of mixture preparation, heat transfer, etc. Nevertheless, it is felt that the design outlined represents a significant step forward for a burner applicable to industrial use.

The stability limits of this burner are shown in Figure 2. It will be noted that it is possible to operate with stability through a turn-down ratio of about 5:1. The lean limit is determined by blowing out of the flame; the rich limit is defined as that point where flame appears at the gap between the air nozzle and vaporizing tube. It will be noted

that this rich limit breaks back rapidly to the lean side at low flows.

When operation is in the stable range, visual inspection of the burner shows a clear, transparent flame zone in the combustion chamber, with a short tip extending from the chamber exit. The color of the flame is pale blue, and its luminosity is very low. In general it has the same appearance as a gas flame such as that seen when propane or natural gas is burned with air. The flame seats at the downstream end of the vaporizing tube. The tube operates at a red heat, showing a somewhat cooler zone if part of the oil spray is reaching its surface. Tube-temperature measurements show values in the region of 2,000° F. When viewed through a sight glass in the back plate, the oil spray can be seen largely to disappear as the fuel is vaporized.

Study of various burners of this design has shown that the stability limits tend to shift somewhat with changes in size or capacity. There is a tendency for the rich limit to shift toward stoichiometric as size is increased. And it is also true that a practical operating limit may be found somewhat within the curves shown, depending on the use to which the burner is put. As an example, white smoke will appear in the combustion gases before the lean blowout point is reached. This would imply that the excess of air is such as to reduce operating-temperature levels sufficiently to leave some fuel unvaporized until too late in its passage to burn completely. Or, as an alternative explanation, it might be suggested that momentary variations in mixing produce pockets of mixture the composition of which lies below the lean limit of flammability, thus permitting vaporized fuel to pass through without burning. At any rate, operation at or near such a point is likely to result in a gradual accumulation of carbon downstream in associated equipment into which the burner gases are flowing.

The approach to the rich limit offers a different problem. The recycling gases, which in the middle of the range show only excess air and products of combustion, begin to show a content of combustible material. As this increases, a condition is reached where carbon will start to deposit, usually in the annular recirculating passage or in the gap at the air nozzle or in both. If allowed to develop sufficiently, this deposit will begin to reduce the recycling flow, thus diminishing the heat available for vaporization, and the operation of the burner will deteriorate progressively. From the practical viewpoint, however, the important thing is that it is still possible to operate such a burner indefinitely at

(*Continued on page* 110)

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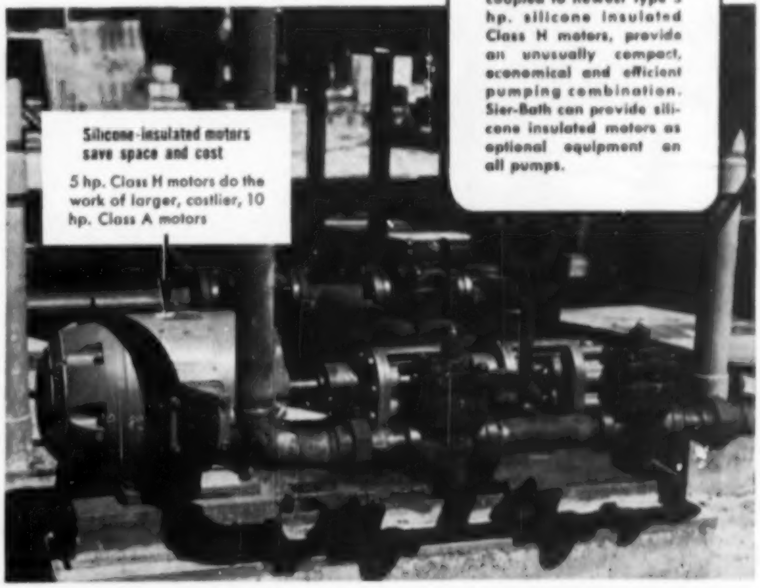

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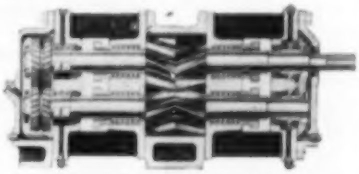

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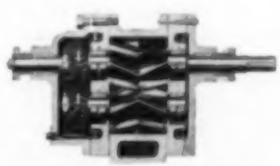

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INDUSTRIAL BURNER

(Continued from page 109)

mixture ratios richer than stoichiometric, thus producing a reducing gas where such may be required. Normally the burner is set up to operate along a median line of the stability range, varying from 105% theoretical air at full output to 140% at the low-fire point. In typical installations the fuel and air valves are linked together in such a manner that the resulting mixture ratio will follow the desired curve.

A further problem which has been encountered as burner size is increased is rough burning. The normal sound of the burner, which is that associated with gases moving at reasonably high velocity, becomes irregular and punctuated with random pulsations. Under some conditions a resonant situation will develop where, although the frequency is moderate, the amplitude is sufficiently great to be disagreeable. This type of phenomenon is common to all high-capacity combustion equipment, and it has received much attention in recent years in connection with ramjets and rockets. Although coupling mechanisms can be suggested, here as in most cases of actual equipment it is difficult to identify the specific culprit. The approach so far has been to cure such troubles by varying the burner adjustment until the noise disappears. Such variations may include relocation of the fuel nozzle and modification of the combustion-chamber shape. Unfortunately the opportunity to study this problem in relation to this type of design has been limited. It has been observed that roughness and resonance appear to be associated with rich-mixture conditions, at least locally. More often than not the occurrence of noise coincides with the appearance of flame in the recycling passage, and this of course would depend on the presence of combustible material in that zone. At present an effort is being made to determine the manner in which this zone is supplied with a rich, unburned, or partially burned mixture. It may be that a characteristic of this design is to tend to concentrate fuel near the wall of the vaporizing tube as size increases; consideration of rate of boundary-layer growth with increasing diameter would support this. Another possibility is that lack of axial symmetry in the fuel spray leads to rich streaks traveling the length of the tube. There is some visual evidence to support this. And a third possibility is that conditions sufficient for adequate mixing in the larger sizes have not been provided, and so rather large eddies of widely varying fuel-air ratio are produced. The partial improvement gained by placing a coarse-wire screen in the air nozzle may point to this as a contributing cause. All three mechanisms would tend to become more important with increasing size, and it may well be that they act in combination to produce the observed effects.

In this case a knowledge of the steps involved in the resonant type of vibration might assist materially in its elimination. It does not seem likely that the feedback of pressure pulsations would affect fuel-delivery rate, since the oil is supplied to the nozzle at 400 lb./sq.in. gauge in the larger burners. It might, however, have an effect on spray angle, causing the point of impingement of fuel on the vaporizing tube to move back and forth rapidly. Whether or not this would tend to regenerate the pressure pulse in the combustion space is debatable.

Other Applications

Mention should be made of current activities to extend the application of this burner design. The importance of adapting this design to the burning of heavy fuels of the residual type is readily apparent, and a considerable effort has been placed on such development in recent years. (The interest and support of the Bureau of Ships, U. S. Navy, has materially assisted in this endeavor.) The point has now been reached where successful operation has been achieved in burners rated at 10 million B.t.u./hr. output. The chief difficulties lie in the nature of the fuel, as much higher temperatures must be reached to gain a substantial degree of vaporization, and complete volatilization is impossible. The design now employed was the result of the same reasoning as applied to the light-oil burner. The one significant difference is the provision of a series of circumferential slots in the refractory lining of the combustion chamber. Air is led to these from the head portion of the burner; its function is to prevent the development of hard carbon deposits on the chamber wall. As is true in any system burning fuels of this type, the carbon-deposition problem is a troublesome one. A better understanding of the formation of these hard, cokelike solids would materially assist in preventing them. Their stability, in terms of refusal to burn at extreme temperatures, is surprising and would seem to indicate a rather critical requirement in oxygen percentage in the immediately adjacent gas stream.

Rather than enter into a lengthy discussion of this problem, suffice it to say that empirical adjustment of the burner design has led to reasonably successful operation. The visible flame extending beyond the combustion chamber is

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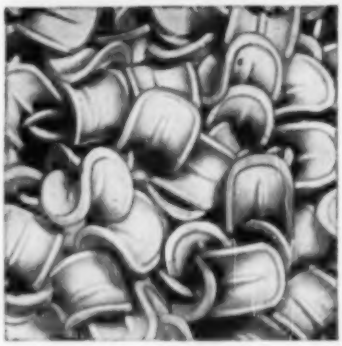

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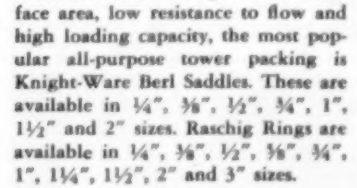

longer and more luminous than in the case of the distillate fuel; it is felt that this will always be true to some degree. When the fuel is fired into air heaters or similar equipment a certain amount of sooty deposit occurs on cooler-wall surfaces; this again is felt to be inherent in the use of heavy fuel. There is a point here, however, which has considerable potential importance. It is not considered unreasonable to expect that the noncombustible residue, i.e., the ash or slag, resulting from the burning of heavy fuels in such a burner may differ in its properties from that formed in conventional combustion systems. This would be based on the thought that the time-temperature history of the fuel particle is of a different type. If such a difference does exist which affects either the deposition or corrosive properties of such deposits, it may have a useful bearing on the problems of slag accumulation and resulting corrosion. These problems are of considerable importance in connection with high-temperature situations of the type found in boiler superheaters, open-cycle gas turbines, and air heaters for closed-cycle gas turbines. At present there are only tentative indications that such differences may exist, but they are regarded as sufficient to encourage further investigation.

With its characteristics of high throughput, good stability, and good controllability, there is no reason why a burner of this type should not be considered as a reactor for other applications. One of the first attempts of this sort has been to apply the technique to the burning of sulfur, in connection with the formation of sulfur dioxide for sulfuric acid production. A burner has been supplied for a pilot installation, and early data show promising results. Similarly, it is expected that the oxidation of phosphorus will soon be attempted.

As a final thought to indicate a limit to which such advances in the field of industrial burners may be carried, the reader is referred to the theoretical discussion by Avery *(2)* of systems where instantaneous mixing is assumed; for such a case he estimates the ultimate space-heating rate for a hydrocarbon fuel to be in the region of 500 million B.t.u./(cu.ft.)(hr.) at atmospheric pressure.

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1. Johnson, J. A., and R. H. Eustis, Paper 52-A171, *Am. Soc. Mech. Engrs.* (1952).
2. Avery, W. H., "Fifth Symposium (International) on Combustion," p. 86, Reinhold Publishing Corp., New York (1955).

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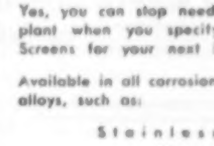

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RESEARCH NEWS

New vacuum-fusion device for measuring to within 5/10,000ths of a per cent the carbon content of steel is shown being operated at U.S. Steel's new Research Center in Monroeville, Pa. Designed and developed by personnel of the Research Center, the new apparatus measures the carbon dioxide generated by burning a steel sample in pure oxygen.

The use of chemically treated soil alone as a subgrade for black top or concrete roads appears possible with a new chemical now under test by the Indiana Highway Commission. The chemical, dioctadecyl dimethyl ammonium chloride, is made from tallow, imparts considerable hydraulic stability to many types of soil. Developed by Union Starch and Refining Co., with the cooperation of the Chemical Division of Armour & Co., the chemical could sharply reduce costs and labor. Tests to date are remarkably encouraging. □

Installation of a complete pilot plant for production of polyurethane foams is the latest development from the Emulsol Division of Witco Chemical. Installed at Emulsol's Chicago laboratories, the new unit does not indicate Witco intends to enter the production of the foam, but only to sell more of its raw materials. □

Unusual flexibility in piping and equipment layout, so as to permit quick and simple process changes, features the new resin development facility being built at Houston, Tex., for Shell Chemical by Walter Kidde Constructors. □

As part of a divisional realignment begun two years ago, American Cyanamid has consolidated all its research activities into a single division under the direction of Kenneth H. Klipstein.

A broad and unique study of the lubrication of dryer roller bearings used in pulp and paper mills is now in its fourth year at the University of Maine. Aim: to determine the role of the lubricant in bearing failure. Sponsored by The Texas Co., the study is expected to yield new fundamental information of great value. □

Agreement has been reached on the acquisition of Cosden Petroleum Corporation by W. R. Grace & Company. Merger basis is 1.025 shares of Grace common for each share of Cosden common. Agreement is now being submitted to the stockholders of each company for final action.

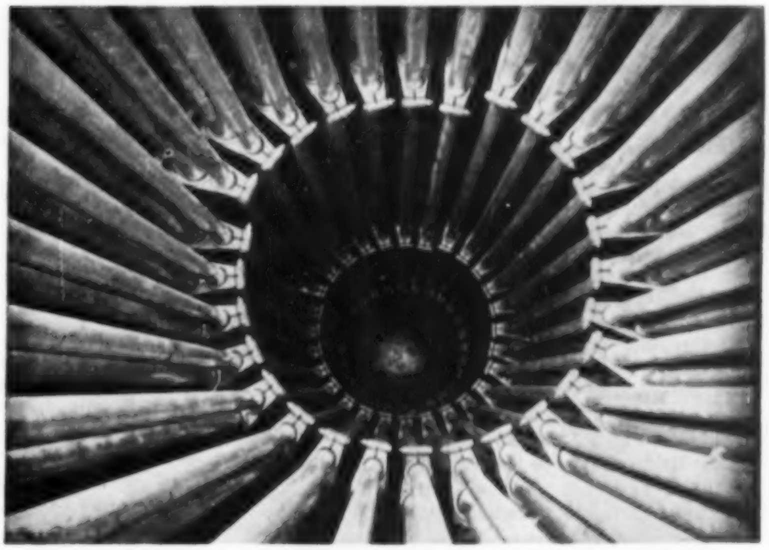
Two research associateship programs in the natural sciences on the postdoctoral level are now available from the National Academy of Sciences-National Research Council, Washington, D. C. Demonstrated ability in creative research is required, pay will be $6390/yr.

Chemical engineers are prominent on the staff of Resources Research, Inc., a new firm of consultants specializing in solving air and stream pollution problems for industry and governmental agencies. □

A multi-million-dollar research center will be built in Bloomfield, N. J., by Colgate-Palmolive. Both applied and basic research will be consolidated there.

Laboratory facilities for General Dynamics Corp. will be constructed in San Diego, Calif.

Heat is the most destructive enemy of rubber products. This new machine, developed by Firestone, is designed to test rubber up to 800° F. Controlled from outside, the electrically heated tester maintains constant interior temperatures, is being used to compile new data in the development of high heat resistant synthetic rubbers for industry.



Ruggles-Coles STEAM TUBE DRYERS

- Ruggles-Coles Steam Tube Dryers have been supplied fabricated of aluminum, nickel, monel, inconel, stainless steels and other alloys to provide protection against corrosion and contamination. All fabrication is to code requirements.
- The continuous siphon discharge of condensate is independent of speed of rotation of the shell. (See "A")
- Automatic air vent for each tube eliminates loss of tube heating surface at the feed end of the dryer. (See "B")
- These extra advantages of the Ruggles-Coles Dryer mean continuous maximum output without operating attention and elaborate control devices.

Complete specifications upon request.
Bulletin 16-D-40.

Cutaway of Ruggles-Coles Steam Tube Dryer showing spiral feeder, air vents, steam header and condensate siphon.

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NATIONAL LEAD TAKES OVER AT MONTICELLO

AEC's uranium processing mill at Monticello, San Juan County, Utah, will now be operated by the National Lead Company.

The Monticello uranium mill, operated heretofore by the Gallagher Co., Salt Lake City, has now been taken over by National Lead. Gallagher did not wish to renew its contract, and National Lead, long experienced in the field, has agreed to assume the job.

National Lead already operates many plants for the recovery of such metals as lead, zinc, titanium, zirconium, nickel, cobalt and antimony.

National Lead operates AEC's ore testing pilot plant in Grand Junction, Colo., and it was in this pilot plant that design for a recent expansion of the Monticello mill was worked out, giving National good experience in the technology of the plant.

National Lead is also contract operator of AEC's feed materials production center in Fernald, O., and the raw materials development laboratory at Winchester, Mass.

A firm entry into the atomic energy field has been made by U. S. Hoffman Machinery Corp. through its recent purchase of a majority interest in Anton Electronic Laboratories, Inc., a pioneer in research, development and production of nucleonic and electronic equipment and components. □

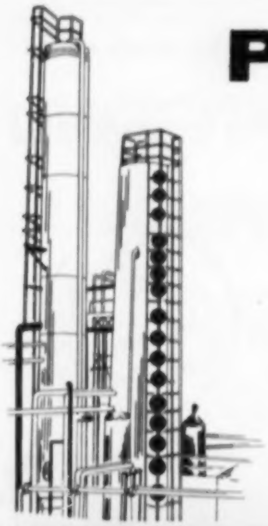
A contract for the construction and installation of an ultrasonic cleaning and degreasing system for an AEC facility that is said to be the largest and most powerful ever conceived anywhere to date, has been awarded to Acoustics Associates, Inc., Glenwood Landing, N. Y. □

A contract to supply complete control instrumentation for a critical assembly, essentially a zero power nuclear reactor which operates at very low wattage, has been awarded to Leeds & Northrup by Combustion Engineering of New York. The critical facility, to be owned and operated by Combustion Engineering, will be used for low power level tests of typical cores for the submarine nuclear propulsion unit Combustion will build for AEC. □

The AEC's program for vanadium and uranium procurement and concentrate-receiving in the Western United States will be operated by Lucius Pitkin, Inc., N. Y. The company will be responsible for the receiving and stockpiling of uranium ores and concentrates and their evaluation for the purpose of paying producers. □

A contract for the purpose of determining the technical feasibility of applying nuclear power to Transportation Corps equipment used in land and water operations, has been awarded to the Nuclear Development Corp. of America by the Dept. of the Army. □

A "hot" radiochemical laboratory is being built by Nuclear Development Corp. of America at its Nuclear Experimental Station at Pawling, N. Y. Purpose: To study the effects of radiation on fuel elements and structural components of nuclear reactors by examining test specimens after they have been irradiated in a test reactor. A secondary use will be to study the effect of radiation on non-reactor materials.



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NUCLEAR ACTIVITIES COUNCIL SET UP IN PITTSBURGH

Purpose of new organization is to act as a central agency to keep abreast of developments in nuclear science and technology, and to help develop the field in the Pittsburgh area.

The new Pittsburgh Nuclear Activities Council is made up of representatives of 16 technical societies active in the area. At the recent organizational meeting, E. B. Gunyou, Koppers, the representative of A.I.Ch.E., was elected president, and S. B. Gunst, Westinghouse, representing the Physical Society of Pittsburgh, was elected secretary-treasurer.

To accomplish its purpose, the Council will coordinate the activities of member societies, investigate the need for industrial training courses, inventory the area's industrial and institutional facilities for nuclear research, and provide a central nuclear information service agency. In addition, the Council plans to sponsor a series of inter-society lecture courses on nuclear science and act to assist member societies in obtaining qualified speakers in the field.

Societies not yet officially represented on the Council are invited to contact T. E. Stelson, Civil Engineering Dept., Carnegie Tech, to arrange for participation.

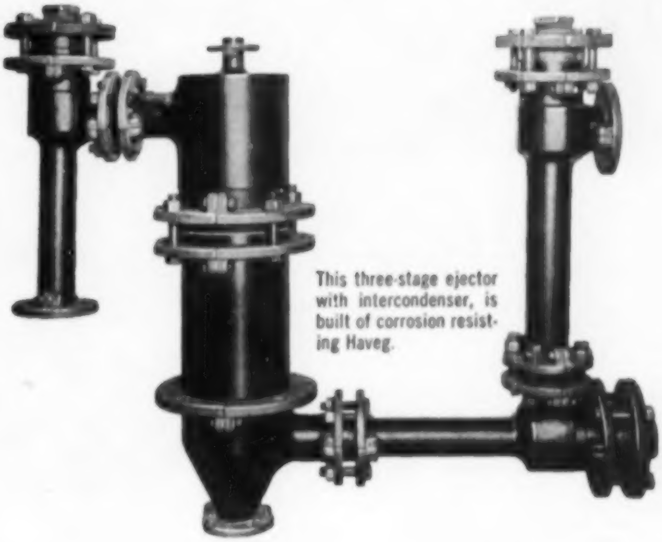
—*M. M. Ramer*

Most recent application of porous metal filters — corrosive slurries in atomic energy plants. Valuable for filtering where ceramics or other filter media cannot withstand pressure, high temperatures or corrosive conditions, the filters are metal sheets that can be welded, sheared, bent and otherwise fabricated. Made by Micro Metallic Corp. of Glen Cove, N. Y., the sheets are fabricated from nickel, stainless, monel, or similar metals, are highly corrosion resistant and strong. □

Ordnance engineering functions will be added to AEC's weapons development activities at Livermore, Calif. The new function will be carried out by Sandia Corp., Albuquerque, N. M., in support of the Univ. of California Radiation Laboratory, Livermore. □

Uranium Prospectors Co., Grand Junction, Colo., has been bought by Vitro Corp. of America and will become a wholly-owned subsidiary. The purchase expands the supply of carnotite ore reserves for Vitro's Salt Lake City mill.

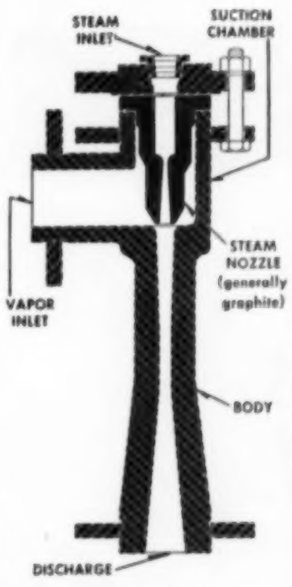
Designed to handle corrosive vapors



This three-stage ejector with intercondenser, is built of corrosion resisting Haveg.

ELLIOTT *Steam Jet* EJECTORS

TYPE H



Cross-section, showing construction details of Type H ejector. Conventional split flanges are used. Nozzle is easily replaceable.

When it comes to maintaining vacuum, while handling highly corrosive vapors, you can't beat these durable Elliott Type H ejectors. Made of Haveg, Permanite or similar corrosion-resistant synthetic resin material, they'll stand up to hydrochloric and sulphuric acids, wet chlorine, caustic, benzene and many other corrosive vapors, including some of the chlorinated aromatic compounds.

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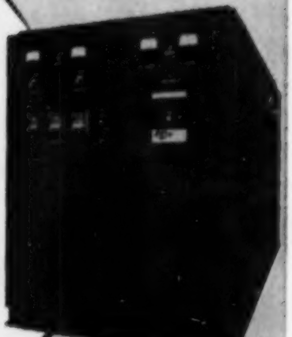

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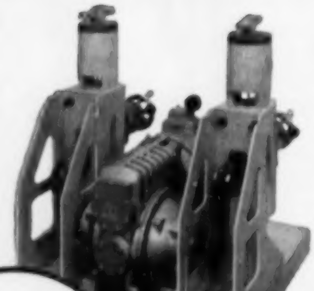

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OVERSEAS NEWS

Representatives of the Japanese Industrial Machinery Manufacturers visit Worthington's Harrison, N. J., Division. Prime purpose of the group is to study the efficiency methods and procedures of U. S. firms engaged in the manufacture of machinery for the chemical, mining, power generation and shipbuilding industries.

The Republic of the Philippines has been chosen as the site for the new Asian Nuclear Center which was proposed by the United States at the Colombo Plan Meeting held in Singapore last October. The U. S. is now preparing to move rapidly with the initial plans for the establishment of the Center, will provide funds for the laboratory facilities and equipment, will supply a reactor to serve research and training purposes. □

The Scaling-Up of Chemical Plant and Process will be the subject of a major meeting of British and Netherlands chemical engineers to be held in June, 1957, in London.

Main object of the meeting will be to discuss and illustrate principles, both theoretical and practical, and the experience of industry will be heavily drawn upon. □

African Pyrethrum Development, Inc., N. Y., announces that plans for erection of the world's largest pyrethrum extraction plant outside the U. S., in Nakuru, Kenya, Africa, have been laid before American and European equipment manufacturers.

Capacity of the plant is expected to be 2,500-3,000 tons of pyrethrum flowers per year, and the facility is planned for future expansion. Extracted product is pyrethrin, active agent in the daisy-like blooms which, when blended into aerosol and other sprays, forms an insecticide harmless to warm-blooded life. □

A new polyethylene plant using the Phillips Petroleum Company low pressure process will be erected in France jointly by Societe Rhone-Poulenc and Societe Kuhlman. □

Controlling interest in Edeco Rock Bits, Ltd., of Manchester, England, has been bought by Dresser Industries, in association with the English Steel Corp. and the English Drilling Equipment Co. By means of an interchange of engineering and manufacturing information between the new British enterprise, to be called Security Rock Bits, Ltd., and Dresser's subsidiary, Security Engineering of Dallas, products of both companies will be identical.

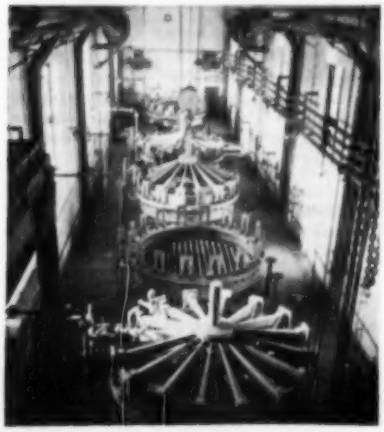
Dresser has also concluded an agreement with Ruston & Hornsby, Ltd., of Lincoln, England, to manufacture and sell in the United States the famous Markta gas turbine, a prime mover particularly suited to chemical, gas and oil applications. □

A joint million dollar investment in Brazil to construct a plant in the Sao Paulo area for the manufacture of permanent magnet alloys for use in the processing industries, has been undertaken by W. R. Grace & Co. and Eriez S. A., Produtos Magneticos e Metalurgicos, a wholly owned subsidiary of Eriez International Corp., Erie, Pa. □

An Australian subsidiary with offices in Sydney has been formed by Infilco, the company's third foreign subsidiary. A fourth such company is in the process of formation in Japan. □

Contracts for the expansion of the Union of Burma's Applied Research Institute at Rangoon, and for metallurgical and mineralogical research, have been awarded to Armour Research Foundation of Illinois Tech. Involving some $200,000, the programs are aimed at developing Burma's resources. □

These filters are part of Poland's giant Oswiecim chemical plant. Located in the south, near Krakow, the Oswiecim plant is expected to produce some 25% of Poland's chemical production at the end of the current Five Year Plan (1956-1960). The chemical industry itself is expected to become the second largest in Poland.



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FUTURE MEETINGS and Symposia of the Institute

Air view of Pittsburgh's "Golden Triangle."

MEETINGS **SYMPOSIA**

■ **PITTSBURGH, PA.**

Sept. 9-12, 1956. Wm. Penn Hotel.

TECHNICAL PROGRAM CHAIRMAN: Carl C. Monrad, Carnegie Institute of Technology, Pittsburgh, Pa.

Mixing

CHAIRMAN: J. H. Rushton, Dept. of Chem. Eng., Purdue U., Lafayette, Ind.

Distillation Computation Methods

CHAIRMAN: Wayne C. Edmister, California Res. Corp., Richmond, Calif.

Scientific Aids to Management (Chemical Engineering Operations Research)

CHAIRMAN: George D. Creelman, Creelman Associates, 10524 Wilbur Ave., Cleveland 6, Ohio.

Case studies showing a wide variety of methods and techniques in applications of operations research in chemical engineering.

Explosions in Chemical Engineering

CHAIRMAN: G. H. Damon, 366 Ashland Ave., Pittsburgh 28, Pa.

Symposium on gas and dust explosions.

Unit Operations in Nuclear Engineering

CHAIRMAN: George Sege, General Electric Co., 2155 So. First St., San Jose, Calif.

How a basic training in chemical engineering fits into the work involved in the field of nuclear engineering, discussing results of unit operations researches done in conjunction with atomic energy projects.

General Papers

■ **ANNUAL—BOSTON, MASS.**

Dec. 9-12, 1956. Hotel Statler.

TECHNICAL PROGRAM CHAIRMAN: W. C. Rousseau, Badger Mfg. Co., 230 Bent St., Cambridge 41, Mass.

Extraction of Hydrocarbons for Chemical Use from Pipeline Gases

CHAIRMAN: E. E. Frye, J. F. Pritchard & Co., 210 W. 10th, Kansas City 5, Mo.

Filtration

CHAIRMAN: F. M. Tiller, U. of Houston, Cullen Boulevard, Houston 4, Tex.

The flow of liquids through compressible media, with experimental and theoretical papers.

Low Temperature Techniques

CHAIRMAN: Clyde McKinley, Air Products Inc., Allentown, Pa.

Papers dealing with gas prepurification for low-temperature processing and the low temperature aspects of heat exchange, refrigeration, distillation and liquid-vapor equilibria, and the properties of materials.

The Sales Engineer in Chemical Engineering

CHAIRMEN: W. E. Hesler, Rodney Hunt Machine Co., 420 Lexington Ave., N. Y. C. 17; E. D. Kane, Cuno Eng. Corp., S. Vine St., Meriden, Conn.

Three Panels: "Introducing Mr. Chemical Sales Engineer," "Training the Chemical Sales Engineer," "Performance Yardstick of the Chemical Sales Engineer."

Afternoon at the Ichthyologists

General Session: "Obsolescence" of Chemical Engineers. Sunday P.M.: Round table discussion.

Deadline—August 9, 1956

■ **WHITE SULPHUR SPRINGS, VA.**

March 3-6, 1957.

■ **PHILADELPHIA, PA.**

March 11 through 15, 1957 (probable)

Nuclear Engineering Division Congress and Atomic Exposition, Philadelphia. "The Fuel Cycle."

Expected to be confined to subjects directly applicable to the overall nuclear fuel cycle. Fuel cycles for power plants and possible plants utilizing high temperature heat are envisioned.

UNSCHEDULED SYMPOSIA

Correspondence on proposed papers is invited.

Laboratory and Pilot Plant Techniques

CHAIRMAN: To be assigned.

Centrifugation

CHAIRMAN: James O. Maloney, Dept. of Chem. Eng., U. of Kansas, Lawrence, Kan.

The theory and quantitative aspects of centrifugation.

Fluidization of Solids

CHAIRMAN: E. R. Gilliland, Chem. Eng. Dept., M.I.T., 77 Massachusetts Ave., Cambridge 39, Mass.

Drying

CHAIRMAN: Ralph E. Peck, Chem. Eng. Dept., Illinois Institute, 33rd Federal, Chicago 16, Ill.

Cost of Unit Operations

CHAIRMAN: John Happel, Chem. Eng. Dept., New York U., University Heights 53, N. Y.

Size Reduction

CHAIRMAN: Edgar L. Piret, Chem. Eng. Dept., U. of Minnesota, Minneapolis 14, Minn.

Filtration & Centrifugation

CHAIRMAN: Horace Hinds, Jr., Corn Products Refining Co., Box 345, Argo, Ill.

Corrosion Resistant Alloy Materials of Construction

CHAIRMAN: G. Fred Ours, Carbide and Carbon, Charleston, W. Va.

Dry Classification of Solids

CHAIRMAN: D. W. Oakley, Metal & Thermit Corp., Carteret, N. J.

Chemical Plant or Petroleum Process Plant Cost Estimates

CHAIRMAN: C. W. Nofsinger, the C. W. Nofsinger Co., 906 Grand Ave., Kansas City 6, Mo.

New Chemical Engineering Construction Techniques

CHAIRMAN: S. A. Guerrieri, The Lummus Co., 385 Madison Ave., N. Y. 17.

LOCAL SECTION MEETINGS

NEW YORK

May 23, 1956, dinner meeting, Brass Rail, 43rd St. & 5th Ave. "The Engineer as a Person."

June 19, 1956, luncheon meeting, Brass Rail, 49th St. & 7th Ave. "Code of Engineering Ethics" or "Garden Chemicals."

September 28, 1956, dinner meeting, Brass Rail, 43rd St. & 5th Ave. "Sonics and Ch. Eng."

WASHINGTON-OREGON

June 11 & 12, 1956, two-day Northwest Regional Meeting concurrent with meetings of A. C. S., American Association for the Advancement of Science, and Pacific Slope Biochemistry Conference. Dr. Walter G. Whitman to be major speaker. For further information contact A.I.Ch.E. Program Chairman L. N. Johanson, Dept. of Chem. Eng., Univ. of Washington.

Details of the A.I.Ch.E. portion of the program:

Economics and Cost Estimation

CHAIRMAN: L. N. Johanson, Univ. of Wash.

"Cost Estimation in the Development of a New Process," J. A. Samaniego, Shell Devel., Emeryville, Calif.

"Cost of Cation Exchange Equipment," Ralph F. Peak and M. M. David, Speer Cartridge, Inc., Lewiston, Idaho and Univ. of Washington.

"Process Engineering Problems in the Hanford Separation Plants," Charles A. Rohrmann, G. E., Richland, Wash.

"Cost Estimation in the Pulp and Paper Industry," J. H. Hull, Crown Zellerbach, Seattle.

Chemical Engineering

CHAIRMAN: W. S. Munro, Monsanto, Seattle.

"Heat Problems in the Disposal of High Level Radioactive Wastes," E. A. Coppinger and R. E. Tomlinson, G. E., Richland, Wash.

"An Evaluation of Iron Oxide-Molybdenum Oxide-Vanadium Oxide Catalyst in the Oxidation of Crotonaldehyde to Maleic Anhydride," F. J. Shelton and R. W. Moulton, Reichhold Chemicals and Univ. of Wash.

"Safety Considerations for Nuclear Merchant Ships," R. A. Fayram, U. of Calif.; H. J. Schneider, U. of Calif.; G. Jenssen, Joint Establishment for Nuclear Energy Research, Norway.

"Equilibria in the System HF (Trace)-HNO_x-H_2O," R. L. Moore, G. E., Richland, Wash.

"Vapor-Liquid Equilibrium, Nitric Acid-Water-Trace Chloride Ion-Application to Nitric Acid Recovery Operation," W. H. Swift, G. E., Richland, Wash.

AUTHOR INFORMATION

Submitting Papers

Procedure to be followed is, in brief:

1—Obtain four copies of "Proposal to present a paper before the A.I.Ch.E.," plus one copy of "Guide to Authors" from Secretary, A.I.Ch.E., 25 West 45th St., New York 36, N. Y.

2—Send one copy of completed form to Technical Program Chairman for meeting selected from above list.

3—Send another copy to Mr. E. R. Smoley, The Lummus Co., 385 Madison Ave., New York 17, N. Y. (Asst. Program Comm. chairman).

4—Send third copy to Editor, Chemical Engineering Progress, 25 West 45th St., New York 36, N. Y. Paper will automatically be considered for possible publication in A.I.Ch.E. Journal.

5—If desired to present paper in a selected symposium, send fourth copy to chairman of the symposium.

6—Prepare five copies of manuscript. Send one copy each to Symposium chairman, Technical Program chairman, or both copies to former if no symposium is involved. Other three copies should be sent to Editor, C.E.P. Presentation at meeting offers no guarantee of acceptance for publication.

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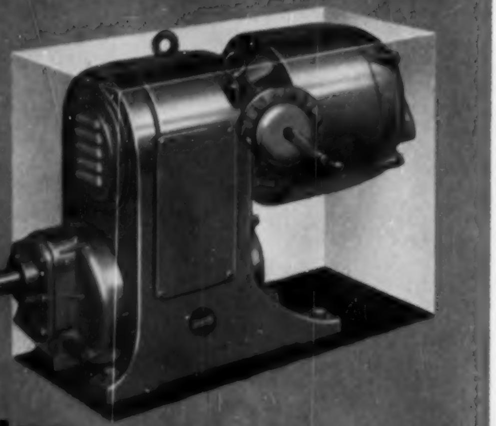

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CANDIDATES FOR MEMBERSHIP IN A. I. Ch. E.

The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on Admissions.

These names are listed in accordance with Article III, Section 8, of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Members and Associate Members will receive careful consideration if received before June 15, 1956, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

Member

Bingham, Richard S., Jr., *Chattanooga, Tenn.*
Bonsall, Norman A., *Bayonne, N. J.*
Cross, Daniel E., *Cincinnati, Ohio*
Eny, Desire M., *Army Chemical Center, Md.*
Frank, John E., *Hammond, Indiana*
Gabuzda, George E., *Wilmington, Del.*
Gates, Charles W., *Elmira, Ont., Canada*
Gilbert, O. G., Jr., *Detroit, Michigan*
Heitzman, Dick, *Scotia, N. Y.*
Hyman, Seymour C., *New York, N. Y.*
Jackson, John C., *Terre Haute, Ind.*
Jones, Robert A., *Tonawanda, N. Y.*
Keleti, Cornelius, *Brockvine, Ont., Canada*
Legal, Casimer C., Jr., *Riviera Beach, Md.*
Liontas, James A., *Philadelphia, Pa.*
McIntire, Robert L., *Bartlesville, Okla.*
McKinney, Claude O., *Whiting, Ind.*

Miller, George T., Niagara Falls, N. Y.
Miller, Robert Leonard, Barberton, Ohio
Prigotsky, M. J., Matawan, N. J.
Puchir, Michael, Morton, Pa.
Pyrciach, Eugene J., Chicago, Ill.
Reames, Rodney B., Angleton, Tex.
Sawyer, Dwight L., Trona, Calif.
Schaefer, Frank A., Philadelphia, Pa.
Schliem, Richard H., La Grange, Ill.
Southworth, Raymond W., New Haven, Conn.
Spitz, S. J., Jr., Pensacola, Fla.
Stern, David R., Whittier, Calif.
Tusson, John R., New Orleans, La.
Wells, Wayne E., Arcadia, Calif.
Weymouth, M. H., Midland, Mich.
Williams, Dean E., Oak Ridge, Tenn.
Woerfel, John B., Western Springs, Ill.
Yoshida, Fumitake, Kyoto, Japan

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Cooper, Kenneth W., Pittsburgh, Pa.
Custer, C. Robert, Monroeville, Pa.
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Davis, John F., Jr., Camden, S. C.
Deskin, Robert C., Charleston, W. Va.
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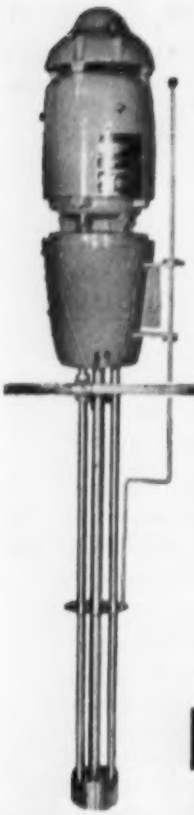

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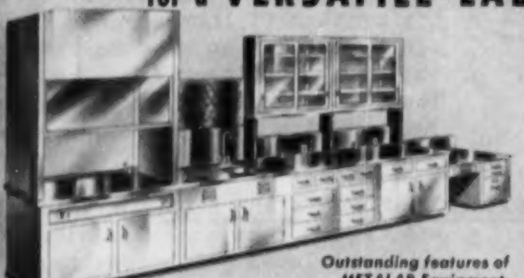

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DEHYDRATION OF NATURAL GAS —A PANEL DISCUSSION

Tulsa Section hears latest operating experiences of four-man engineering panel at its March meeting.

M. H. Rahmes, Stanolind Oil and Gas, L. S. Reid, U. of Okla., O. G. Howe, Oklahoma Natural Gas Co., and A. B. Richert, Dresser Engineering, made up the panel of experts.

Rahmes emphasized that the two types of dehydration units, solid and liquid desiccant, have differing advantages and disadvantages. Solid units produce gas with low dew points, but may have a short desiccant life due to fouling. The latter can be combatted by using a high capacity desiccant, by using a mist extractor, and/or by using a residue-gas cooler to knock out heavy materials.

Left to right, Howe, Rahmes, Reid, and Richert.

Other problems encountered with solid units are: desiccant shattering; plugging and channeling in the bed; corrosion due to low pH water condensing out and to acid gases.

Liquid desiccant units produce a gas with higher dew points, although they can usually meet sales-gas specifications of 6 to 9 pounds of water per million cu. ft. And liquid units have lower fuel-gas consumption. But they often have excessive losses from leaks and poor mist extractor operation, are sometimes troubled with the plugging of filters, although the latter can be minimized by good filter-element design. In the liquid units the reboiler, contactor, and downstream piping are vulnerable corrosion points.

Speaking for two companies in the field, Richert and Howe discussed some practical points. Most of Dresser's ex-

perience has been with custom-built solid-desiccant units of comparatively large size. Average pressure drop is 4 lbs./sq. in., air cooling is usual, some units have "dowtherm" heating. Fuel economy is very important and the desiccant tower is usually insulated on the inside with 2-inch thick asbestos liner. Units are usually downflow to counteract bed sifting. Gas outlet should be in the bottom of the vessel to permit draining any condensed water. Florite of 4 to 8 mesh is usually used as desiccant. Sovabeads, Alcoa's H-151 alumina, and silica gel all give good dehydration and high degree of hydrocarbon recovery.

In the experience of Oklahoma Natural Gas, the amount of dehydration depends on the contemplated end use of the gas. Operating entirely within Oklahoma, the company is not required to dehydrate to 7 lbs./million cu. ft., but dehydrates 20° F. below the prevailing wet bulb. This works well on major systems, but trouble is sometimes encountered in the smaller side lines. The dehydration engineer must strike an economic balance between these two factors.

Future trends in gas dehydration will probably include, according to Reid, shorter cycle times to effect greater recovery of liquid hydrocarbons. Higher reactivation temperatures and high capacity desiccants will reduce fouling problems. Operations will be carried out at higher pressures, and it might be good to dry at high pressure before expansion to lower pressures. Preliminary work indicates that the shape of the bed may have a decided effect on dehydration efficiency when using solid-desiccant units. For liquid units, triethylene glycol is most hygroscopic, is effective up to 3500 lbs./sq. in.

"BULL SESSIONS" FEATURE NEW JERSEY MEETINGS

At the meetings of the New Jersey Section, informal roundtable discussion holds the floor.

After the main speaker has delivered his talk, answered all the questions, the New Jersey section members, like all other section members, take a refreshment period at their meetings. But there is a difference—organized technical bull sessions.

Technical bull session is the phrase used to describe the informal roundtable discussions which New Jersey Section engineers have adopted to give members an opportunity to exchange ideas on technical subjects during the refreshment period at the regular monthly meetings.

After C. S. Cameron's talk on the

(*Continued on page* 124)

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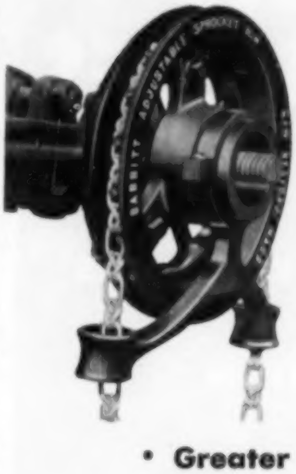

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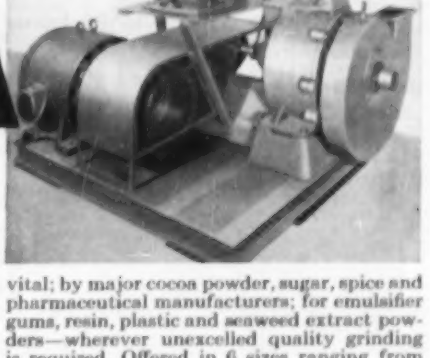

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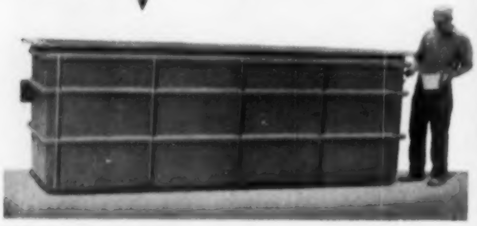

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"BULL SESSIONS"

(*Continued from page* 123)

Cameron, left, and D. Oakley, chmn., lead the question and answer period following the talk.

chemical aspects of the increasing menace of lung cancer at the February meeting, the bull sessions took over with four organized roundtables: Thermodynamics, Reaction Kinetics, Pilot Plants, and Distillation.

One of four roundtable "bull sessions," New Jersey engineers discuss Reaction Kinetics.

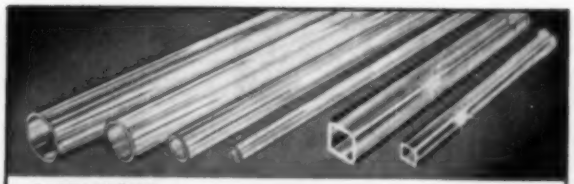
In his talk, Cameron indicated that much progress has been made in identifying chemicals which will produce cancer on the skin of mice. Eventually, chemistry will play a part in the prevention of cancer-producing chemicals from entering the human body, and in the manufacture of compounds which will combat cancer growth successfully.

—P. E. Graybeal

NEW LOCAL SECTION OFFICERS

Officers elected to run their sections in 1956 are: **Atlanta:** J. N. Carothers, chmn., N. R. Maleady, vice-chmn., R. L. Bowen, secy.-treas., J. J. Wimberly, past-chmn., J. L. Gray, W. F. Keffer, W. M. Newton, F. E. Rowe, exec. comm. **Baton Rouge:** L. A. Nicolai, chmn., Alfred Smith, III, vice-chmn., J. B.

(*Continued on page* 126)



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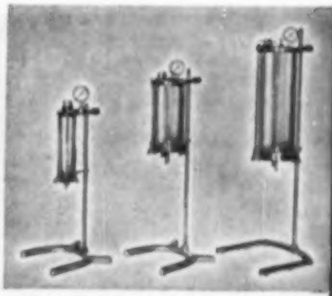

Illustrated above, left to right: Model 9; Model 10; Model 21 and 21-1.

MODEL	CAPACITY Cu Cm	CAPACITY Ounces	SHEET Dia	AREA Sq In
21-1	3750	130	[illegible]	21
21	[illegible]	[illegible]	[illegible]	21
10	[illegible]	[illegible]	[illegible]	9.62
9	[illegible]	9	[illegible]	[illegible]

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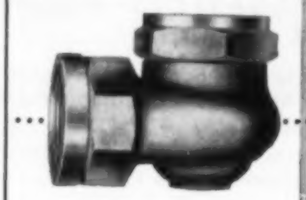

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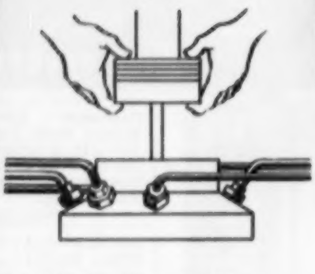

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NEW LOCAL SECTION OFFICERS

(*Continued from page* 124)

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LEGAL PROBLEMS, INDUSTRIAL HEALTH, CORROSION AND VARIOUS TECHNOLOGICAL SUBJECTS OCCUPY LOCAL SECTIONS

Akron Section hears patent problems; Maryland discusses local chemical boom.

It was legal and patent night at Akron at the **Akron Section's** (*T. H. Rogers*) January meeting. G. C. Mack, prominent Akron patent attorney, discussed and analyzed the various patents relating to the tubeless tire, and the factors that would be considered in the pending lawsuits. Turning from law to industrial geography, the **Maryland Section** (*D. E. Evans*) heard, in January, an eminent panel discuss the city of Baltimore as a Chemical Center. Consensus: the greater Baltimore area is the seat of a thriving chemical industry favored by progressive city government, an active Association of Commerce, an alert and forward-looking utilities supply picture, and a market potential extremely favorable to consumer chemicals.

Packed Towers and Tower Packing

In the more technical vein, the **New York Section** (*S. B. Adler*) held a panel meeting in January on the sub-

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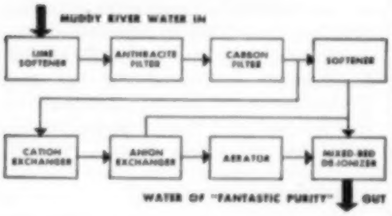

This block diagram shows a typical arrangement for a power company steam plant that must draw its boiler feed water from a nearby muddy river. The Lime Softener takes out suspended solids, turbidity, alkalinity, and organic matter; the Anthracite Filter removes any remaining turbidity; the Carbon Filter removes the chlorine; the Softener provides process water; the Cation and Anion Exchangers remove the dissolved solids such as carbonates, sulfates, and chlorides; the Aerator takes out most of the CO_2; and the Mixed-Bed De-Ionizer eliminates the remaining 4 or 5 ppm of solids, silica, and 5 ppm of CO_2 — to produce water of "fantastic purity."

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ject of Packed Towers and Tower Packing. Max Leva, consulting engineer, analyzed the design problem involved, S. Schwartz, consulting engineer, handled the new developments in the field, and E. G. Scheibel, York Process Corp., presented the operation point of view, comparing experimental data with operating data obtained from commercial size towers. One specific technical problem held the attention of the **Southern California Section** (*F. G. Sawyer*) at its January meeting: the development of an economic method for the desalting of sea-water. The problem is a vital one for southern California industry where the growing shortage of fresh water is acutely felt. The speaker, W. C. Pierce, U. of Cal. at Riverside, stated that desalting sea water does not appear to be economical at this time at least.

High Temperature Microscope

Refractories and Porous Media from Electric Furnaces were discussed at the January meeting of the **Baton Rouge Section** (*M. F. Gautreaux*) by R. W. Brown, Carborundum Co. Brown showed the properties and product characteristics, described the use of these materials in high temperature and corrosive services now requiring alloys or fire-clay refractories. Use of a new research tool—the high-temperature microscope—which can observe reactions at temperatures up to 4700° F., was shown in a film.

Industrial Illness

Two-thirds of all industrial illness, resulting in an annual compensable loss of $100 million, is caused by industrial dermatitis. In talking of this serious problem to the January meeting of the **East Tennessee Section** (*R. F. Hunt, Jr.*), F. L. Oglesby, Tennessee Eastman, pointed out that chemical irritants and sensitizers are one of the major causes of dermatitis. He discussed various means of prevention, but emphasized that the principle cure was avoidance of exposure to the irritant.

Radio-carbon Dating

The interesting nuclear side-light of Radiocarbon Dating, a specialty of AEC Commissioner W. F. Libby, was outlined to the February meeting of the **National Capital Section.** Briefly, cosmic rays introduce radiocarbon into the biosphere making all living things radioactive. At

(*Continued on page* 128)

below 800° F.
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NUCLEAR ISSUE

JUNE, 1956

Basic papers on chemical engineering theory applied to the nuclear field will appear in the June issue of the

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A.I.Ch.E.

News of the Field

FROM LOCAL SECTIONS

(Continued from page 127)

death the immutable rate characteristic of the radioactive decay of radiocarbon begins—half-life is 5600 years. By the determination of residual radioactivity, the antiquity of many sites and events can be determined.

Corrosion Control

At the **Rochester Section** (*J. E. Millard*) February meeting, F. J. Honn, F. W. Kellogg Co., spoke on "Kel-F" products for corrosion control. Kel-F products are polymerized forms of chlorotrifluoroethylene. They are applied as dispersions, sprayed and baked, or as laminated sheets. The finished coatings have high chemical resistance and thermal stability. At the **El Dorado Section** (*D. S. Thomas*) in February, O. DeGarmo, Monsanto, discussed the development and use of pesticides and other agricultural chemicals.

Radar Stations

The famous "Texas towers" long used for oil drilling off Texas, and now being installed as radar stations far out in the Atlantic, are monuments to engineering skill in the face of great difficulty, according to V. Cates, Anderson-Nichols & Co., speaking to the February meeting of the **Boston Section** (*A. S. Collins*).

Distillation Trays

W. C. Schreiner, M. W. Kellogg, presented the subject of the perforated distillation tray to the March meeting of the **New Haven Section** (*R. W. Mickelson*). He compared costs of perforated trays with other types of bubble trays, discussed design factors and field information concerning performance in towers. Climax of the talk was Schreiner's step-by-step design of a perforated tray.

Pulp and Paper

The **Coastal Georgia Section's** (*J. C. Bowers*) March meeting was a joint one with the Herty Foundation, the subject therefore concerned the pulp and paper industry and many guests from the industry were present. L. E. Wise, Institute of Paper Chemistry, led the program with a detailed talk on The Industrial Significance of Some Neglected Components of Wood Pulp. D. Weatherhorn, Southern Paperboard Corp., discussed the Development of High Yield Kraft Pulping as done by his company, C. E. Cone, Herty Foundation, briefly surveyed bark utilization, and R. C. Sproull, Herty Foundation, presented some observations on continuous cooking.

Gasketed Joint Maintenance

The two major factors that must be considered in the maintenance of a gasketed joint are: the selection of the correct gasket material or construction, and its proper installation. H. H. Dunkle, Johns-Manville, then went on to develop in detail the factors affecting gasket selection for a given application before the March meeting of the **Detroit Section** (*E. Garelis*). He also covered various points on installation technique that might be helpful in preventing leaks or trouble-shooting.

Solar Furnaces

Solar furnaces came under scrutiny at the January meeting of the **Northern California Section** (*E. J. Cahill*). These furnaces, according to P. Duwez, Cal. Tech., use large mirrors—up to 40 feet in diameter—to concentrate the sun's rays on a small target. Temperatures at the target are very high, with 9000° F. being theoretically possible and over 5000° F. actually reached to date. The furnaces make possible advanced studies of very high melting alloys and of high temperature chemical reactions.

Instrumentation Control

In a well illustrated talk to the **Detroit Section** (*E. Garelis*) J. D. Dunlap, Brown Instrument Div. of Minneapolis-Honeywell, covered the different modes of control of instrumentation, i.e. on-off, proportioning, and proportioning and reset as applied to both electric and pneumatic controls. He went on to analyze the operation of various control devices such as motor valves, dampers or contactors with different control methods. He also discussed the different types of control records produced by the various control forms and equipment, using a simple process as example.

ASPIRING LAKE CHARLES CLUB MAKES IMPRESSIVE PROGRESS

In its first full year of operation the **Lake Charles Chemical Engineers' Club** (*V. J. Yeakley*), which is aspiring to future Institute affiliation as a local section, has had an outstanding series of well-attended programs. At this season's meetings subjects have been: Hydroforming, with emphasis on corrosion and erosion; fuel resources; petrochemicals, emphasizing detergents, and heat transfer. The March meeting heard a major talk on the Application of Electronic Digital Computers in Chemical Engineering.

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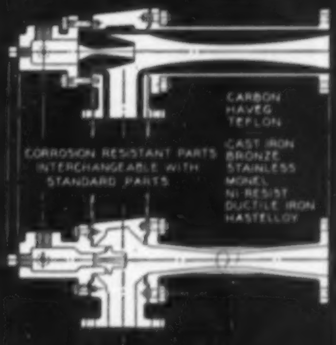

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people

TOP CHEMICAL ENGINEERING STUDENT WINS RHODES SCHOLARSHIP

U. of Miss. chemical engineering senior with a straight A average will have two years' advanced physics study at England's Oxford Univ.

Jess Woods, aspiring chemical engineer from Gary, Ind., has won a coveted Rhodes scholarship in recognition of his outstanding academic record (it will be the best in the history of Mississippi's Engineering School if he maintains it), and his "well-rounded" character.

Jess, who is a member of many university clubs, including being treasurer of the university's Chemical Engineering Club, last year won the national award of The Society of American Military Engineers for the outstanding junior in the School of Engineering, and the American Society of Professional Engineers' award for Mississippi.

Procter Thomson among five American engineers awarded Missouri Honor Awards by the University of Missouri. Thomson, who is with Procter & Gamble in Cincinnati, was cited for his work in quality control, as well as for pioneering in the application of statistical methods to chemical engineering problems.

Herbert E. Silcox assumes duties of technical director, a newly created position in the chemical division of Merck, Rahway, N. J. With the firm since 1942, Dr. Silcox in this position directs a scientific group for product and formulation development, as the basis for technical service to the various customer industries.

Hermann C. Schutt, formerly a consultant with the Badger Process Division of Stone & Webster Engineering, establishes consulting offices in Boston, Massachusetts. His field includes the petroleum and chemical industries on the production of acetylene, ethylene and other reactive hydrocarbons as well as the synthesis of organic chemicals from these basic materials.

R. D. Glenn is appointed assistant works manager for Carbide and Carbon Chemicals, N. Y.

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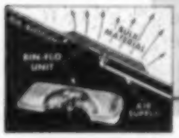

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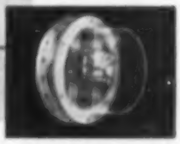

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people

Walter H. Pahl to division engineer for the chemical products group at Minnesota Mining & Manufacturing, St. Paul, Minn.

In Hoboken, N. J., General Foods' Central Laboratories promotes **Robert L. Banta, Jr.** and **Howard J. Newby** to section heads, both in engineering and commercial development.

George A. Day is appointed to newly created position of technical director at Brown Co., Berlin, N. H. He supervises technical affairs, including new developments, research, and quality and process control. **Douglas H. McMurtrie,** who has been research associate in pulp, becomes director of research.

Gabriel Appleman appointed assistant director of engineering at Foster D. Snell, New York.

Fred Ghannam joins Ford Motor Company's development department, Dearborn, Michigan.

L. Stewart Mims appointed by Bell Aircraft Corp. to head newly formed nuclear engineering department in Buffalo, N. Y. Mims, one of the engineers responsible for development of the atomic powered submarine "Nautilus," is a graduate of the government's Oak Ridge School of Reactor Technology.

Raymond W. Hess, coordinator of pollution research for Allied Chemical & Dye, National Aniline Division, awarded the 1956 Jacob F. Schoellkopf Medal by the Western N. Y. Section of the A.C.S.

The A.E.C. transfers **Edward J. Grabowski** to its isotope separation branch of the production division in Washington. He was formerly assistant to the area manager for production in the Dana Plant, Newport, Indiana.

The chemical and metallurgical division of General Electric, Pittsfield, Mass., announces the appointment of **John L. McMurphy** as manager of a special study-team on the division's insulation businesses.

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people

Gordon W. Duncan is named assistant manager of the office of scientific liaison, Esso Research and Engineering, which coordinates the firm's activities with universities, institutes, scientific societies and scientific consultants.

Paul T. W. Strub joins the Fluor Corp., Ltd., Los Angeles, as assistant to the president. Formerly with Calor Gas Co., San Francisco, Mr. Strub has also been with Great Lakes Carbon, Reconstruction Finance Corp., and Standard Oil.

Jet Research Center appoints **James H. Wiegand** vice president and technical director. He was recently chairman, department of chemistry and chemical engineering, Southwest Research Institute, where he had been since 1953.

C. R. Nelson and **D. J. Pompeo** of Shell Development, Emeryville, Cal., selected by Northern California Section of A.I.Ch.E. and Instrument Society of America, respectively, as outstanding engineers in the Bay area for 1955.

James B. Allen made supervisor, process improvement, for Pittsburgh Coke & Chemical's chemical division. He has been with Koppers Co., and Tennessee Eastman.

James R. Fraser, new chief engineer of H. K. Ferguson, Cleveland, Ohio. He supervises all of Ferguson's engineering locations throughout the country.

Bernard V. Baus of Du Pont is promoted to technical superintendent of the Victoria plant, Texas. Mr. Baus was formerly with the Belle Works at Charleston, West Virginia, as assistant and technical superintendent.

Herbert Kay named manager, catalyst development, for Climax Molybdenum. He is responsible for the development of uses of molybdenum in corrosion inhibitors, intermetallic compounds and ceramics as well as catalysts.

John M. Jordan joins the staff of Esso Research and Engineering products research division in Linden, New Jersey. **John F. Jones, Jr.,** and **Arthur M. Thomas, Jr.,** are new members of the process research division. The economics division adds **David G. Bowen,** and the petroleum development division takes on **Norman J. Weinstein.**

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Donald Q. Kern, D. Q. Kern Associates, conducted the third annual Heat Transfer Conference sponsored by Oklahoma A. & M. College.

The Girdler Co., Louisville, Ky., promotes **Robert E. Deatz** to assistant chief engineer in charge of project and design engineering. **Louis P. Bornwasser** succeeds Mr. Deatz as chief project engineer of fats and oils section.

The Morehead Medal presented to **G. V. Slottman,** vice president, research and engineering, Air Reduction Co. The medal was given by the International Acetylene Assoc. for his work on carbide, acetylene and oxygen technology.

The nation's top industrial research executives name **Thomas H. Vaughn** of Colgate-Palmolive as vice president, president-elect, and director of the Industrial Research Institute. Vaughn is vice president in charge of research and development at Colgate. A chemical engineer, he directed research units for Union Carbide & Carbon and Wyandotte before joining Colgate in 1953.

J. E. Underwood, Jr. joins the research department at Pratt, Read, and Co., Ivoryton, Conn. He was formerly with Minerals Processing Corp. in Syracuse, N. Y., as general manager.

The appointment of **Shea Smith III** as assistant to the president, secretary of the executive committee, and executive offices of the president is announced by Monsanto in St. Louis. **James H. Lum** is promoted to manager of research and development, organic chemicals division. **Ferdinand B. Zienty** to director of research and **Monte C. Throdahl** to director of development, organic chemicals division. **Robert J. Simon** becomes a project engineer for the development department, overseas division, St. Louis.

Werner C. Muller named manager of product development section of U. S. Industrial Chemicals Division of National Distillers, N. Y. Muller, a graduate of Stevens Institute, has been with U.S.I. for the past nine years, and was previously with Carbide and Carbon.

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American Oil announces appointment of **John E. Kasch** as manager of research and development, with headquarters in N. Y. Formerly manager of coordination in the manufacturing department, Kasch joined the firm's refining affiliate in Texas City, Texas, in 1942. He was on loan to the Petroleum Administration for War during World War II.

Election of **S. Crawford Bonow** as vice president of Stein-Davies is announced in N. Y. He was formerly assistant vice-president of Stein-Davies and manager of manufacturing for the parent Stein, Hall & Co., and continues in the latter post.

Richard S. Rhodes, assistant manager, production department of Koppers Co. since 1954, named assistant to the president, a newly created position entailing special responsibility for the firm's capital program and capital appropriations.

George White assumes responsibilities of general manager, General Electric's atomic power equipment department. Before accepting this position, he was executive vice president and a director of the Vitro Corp. of America. Mr. White is responsible for the design, development, manufacture and marketing of G.E.'s commercial atomic power products.

Thomas L. Ward becomes manager of the Alco Products, Inc. plant at Dunkirk, N. Y.

E. Keith McMahon assumes responsibilities as director of development for the chemical paint and metallurgical department of Merritt-Chapman & Scott, N. Y. In this post Mr. McMahon is to project and coordinate plans for further growth of Devoe and Tennessee operations in the chemical, paint and metallurgical fields.

R. W. Swinehart to the post of superintendent of cellulose products in plastics production department of Dow Chemical.

A. G. Edeleanu transfers from California Research Corp. to Oronite Chemical Co. for whom he will be European technical representative.

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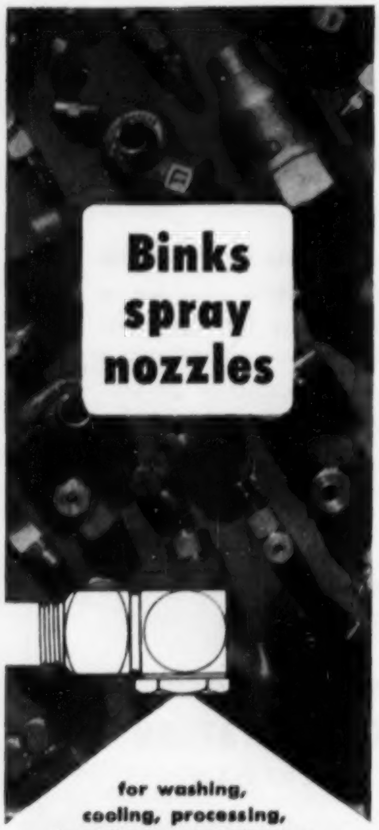

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MARKETING

Blaw-Knox' Chemical Plants Division announces promotion of **Ralph Berger** to manager of special process sales at its midwest headquarters in Chicago. He directs sales and project engineering for all fats and oil processes. Prior to joining Blaw-Knox in 1952, he was with Wraster & Sanger, E. I. duPont, and General Motors.

Gilbert F. Richards becomes vice president in charge of sales of Sharples Corp.

J. Ernest Miller named vice president, sales, for Goodrich-Gulf Chemicals, Cleveland. Formerly sales manager, he joined the firm in April, 1955.

Charles J. Vickers appointed manager of technical sales-service of Colfoam microballoon spheres department, Colton Chemical Co., a division of Air Reduction Co., Cleveland.

Micro Metallic Corp., Glen Cove, N. Y., promotes **Charles H. Hacker** to assistant sales manager.

The appointment of **John T. Castles** as manager of the Elastomer Market Development Unit in the Silicone Products Department is announced by General Electric.

Clayton Ruebensaal becomes director of commercial planning for the Texas-U. S. Chemical Co., jointly owned by Texas Co. and U. S. Rubber. **Martin J. Tierney** has assumed Ruebensaal's former position as commercial development manager of the Naugatuck Chemical Div. of U. S. Rubber.

Salvadore P. Lio is new asst. sales manager for styrene molding materials at Monsanto, Springfield, Mass. Lio has been plant manager of Monsanto Mexicano since 1950.

Van Zandt Williams, a vice president of the Perkin-Elmer Corp., named general manager of the firm's newly formed instrument division, responsible for development, production and sale of analytical instruments.

John W. Pool, Jr., is named manager, sales department, of the chemical division of Koppers Co., Pittsburgh, Pa. He was formerly assistant manager of the chemical div. sales department. **R. F. Seubert** is promoted to manager of the chemical division's eastern district sales in N. Y.

Gifford-Wood Co. announces the appointment of **Walter G. Engler** and **Alfred H. Hallenbeck** as vice presidents. Mr. Engler has been general sales manager since 1951, and Mr. Hallenbeck works manager of the Hudson plant, Hudson, N. Y.

Raymond C. Roloff is sales manager of the newly formed industrial equipment division, Strong-Scott Mfg. Co., Minneapolis.

The assignment of **Richard L. Spetka** to the N. Y. domestic office is announced by the sales office of Cooper-Bessemer Corp., Mount Vernon, Ohio.

Arthur I. Mendolia of the Du Pont electrochemicals department, Wilmington, becomes assistant director of sales. He had been assistant director of research since his transfer to Wilmington in 1954.

Houdry Process announces the appointment of **Dudley Beyler** as product sales engineer in the chemicals division.

William T. Smith assigned to the N. Y. office of Goodyear Tire and Rubber's chemical division as sales representative.

John N. Borda appointed senior market research analyst in American Cyanamid's market research department.

Randall W. Johnson named assistant manager of Trane's transportation sales department, LaCrosse, Wisconsin. He takes charge of transportation, air conditioning and refrigeration equipment with the firm's eastern sales offices having railroad accounts.

Robert A. Gopel, formerly manager of sales personnel development at Koppers Co., is now assistant sales manager of American Aniline Products, Inc., Pittsburgh, Pa.

The sales office of Monsanto Chemical's organic chemicals division, St. Louis, announces two personnel changes: **Frank I. Jones** of Cincinnati, to the N. Y. office, and **August R. Hemphel** of St. Louis, to the Cincinnati office.

Carl J. Siebert becomes sales manager of W-S Fittings Division, H. K. Porter Co., N. Y. He was formerly district manager of the Chicago office.

Brian L. Shera is made assistant sales manager, Pennsylvania Salt Manufacturing Co., Tacoma, Washington.

Carl O. Hedner, sales executive of Yale & Towne Mfg. Co. for 33 years, is named assistant general sales manager of the company's materials handling division.

Frances V. Duffy takes over directorship of sales research for the petrochemical division of Foster Grant Co., Leominster, Mass.

Necrology

G. Edwin White, 52, chairman of chemical engineering department of City College of New York.

Aaron Krus, 34, senior technician, Shell Chemical Corp., Houston, Texas.

Eugene Casson Crittenden, 75, expert on standards of physical measurement and retired as associate director of National Bureau of Standards in 1950.

Seymour Faulkner, 52, consulting engineer with E. F. Drevy & Co., Inc., Florida.

Stafford L. Wilson, 23, graduate student, Princeton University.

F. E. Harlow, 43, division superintendent, Dow Chemical Co., Midland, Michigan.

Allan W. Dow, 89, retired from the position of consultant with the Asphalt Institute, N. Y. C.

Lewis H. Haupt, 66, assistant design project manager, Du Pont, Wilmington, Del.

William Brent Altsheler, 38, project engineer, L. W. O'Donnell & Assoc., Inc., Louisville, Ky.

Paul J. Kolachov, 56, special advisor to the biochemistry section at Armour Research Foundation of Illinois Institute of Technology on special advisory assignment to the Bogota, Colombia, technology laboratory center.

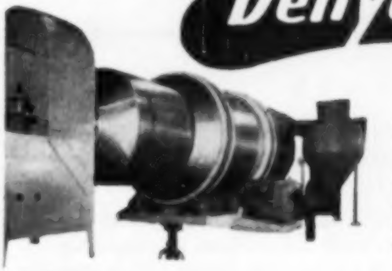
Joseph A. Baker, 58, Chairman of the Board of Baker Perkins, Inc., and President of Canadian Baker Perkins Ltd.

Lewis S. Munson, 82, dye expert, retired from the dye works of Du Pont.

Chemicals are Dried Quickly, Economically

in.... DehydrO-Mat

PAT. PENDING



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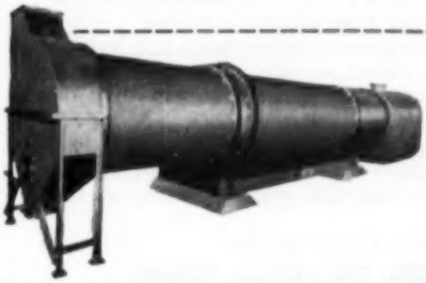

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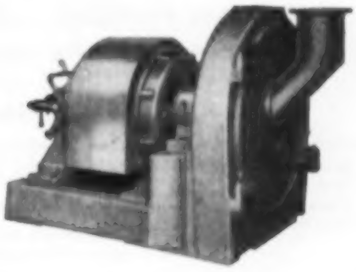

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3. Chemist with some research background for work with research division in liaison with patent attorneys. Some experience in this area essential, and preferably in the petroleum industry.

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These projects are associated with the production and distribution of oxygen, nitrogen and argon as low temperature liquid or gases.

B.S., M.S., or Ph.D. graduates with up to five years' experience are invited to investigate.

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a division of
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Send résumés to: Mr. P. I. Emch
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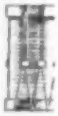

ADDRESS
Dr. F. C. Brooks, Director
CORG, Fort Monroe, Virginia

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TECHNICAL INFORMATION SECTION SUPERVISOR

An individual with an advanced degree in physical science or engineering field, preferably chemistry or Chemical Engineering, to supervise activities of three groups, engaged in (1) technical literature searches, translations and abstracting, (2) technical library and (3) technical files maintenance. Salary open, dependent upon experience.

Please submit résumé to:

Employee Relations Manager
Research & Development Department
Phillips Petroleum Company
Bartlesville, Oklahoma

Phillips 66

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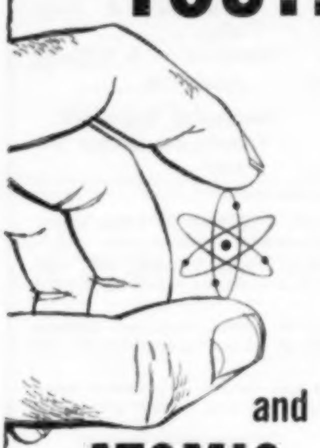

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If you are interested in a non-routine position that will use all of your education and experience, we suggest you investigate the future with the leader in Atomic Power. At Bettis Plant, there are select positions open for specially qualified:

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Write for the booklet "Tomorrow's Opportunity TODAY" that describes opportunities in your field. Be sure to indicate your specific interests.

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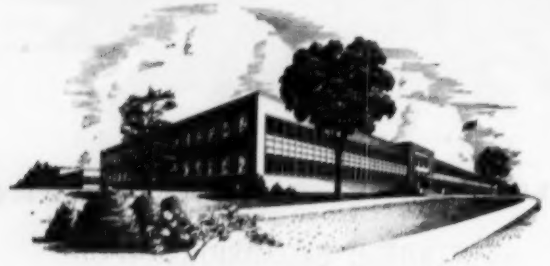

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At least 8 to 10 years experience is required, involving non-metallic inorganic materials for use at high temperatures. (If directly related, time spent in obtaining an advanced degree may be considered part of this experience). Applicant must be a graduate physical chemist, metallurgical engineer, or ceramic engineer, preferably with Ph.D. or equivalent.

Publication of research results in the appropriate classified or open literature is encouraged.

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Expanding chemical plant design group in our engineering and construction division at Pittsburgh needs several project engineers having approximately five years' process design experience. Masters degree desirable. Unusual opportunities for participation in all phases of activities from research through engineering to plant start-up on wide variety of chemical and petrochemical processes.

Write giving details of experience and salary requirement to:

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Koppers Building
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CHEMICAL ENGINEER FOR PILOT PLANT production of new inorganic product now in development. Philadelphia area. Company is old, vigorous, and sound. Excellent opportunity for man with three or four years' experience in production or pilot plant. Give full background, experience and expected salary. Box 21-5.

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By a well-known, established concern manufacturing chemical process equipment, such as liquid and dry mixers—ball mills—extrusion and agglomeration machinery. This is an excellent account, so representative must be high-grade, very active, and familiar with the chemical process, and similar industries.

Reply to:

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The Sherwin-Williams Company desires to employ a recent graduate chemical engineer, age 25-30, for a managerial training position in its pigment division located in Kansas.

Engineer selected will be thoroughly trained in all phases of chemical plant operations reporting directly to the plant Superintendent. Upon completion of training will be assigned to top engineering position in the pigments division. Promotional opportunities range from top managerial engineering position to plant superintendent. Must have supervisory ability as well as interest in plant operations. Experience not necessary.

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Some industrial experience preferred, for diversified work on process and product development and customer service. Division laboratory of national concern located in pleasant smog-free suburb of Los Angeles. Send complete résumé and salary requirements to:

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Highly desirable positions with nationally known, progressive and fast expanding chemical manufacturing company located in New England. Research chemists with experience and a good background in either or both fields will be offered unusual assignments in application work on resins for the textile and paper fields.

Excellent salaries. Outstanding growth potential.

Progressive management offers unique company benefits and advantages.

Send résumé and salary requirements in strict confidence.

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Attention: Mr. P. I. Emch
Refer to ad: CEP-D

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A.I.Ch.E. Members

CHEMICAL ENGINEER—Ph.D. Twenty years' industrial experience in petroleum, petrochemicals, organics. Desires responsible position in development, design or technical service. Box 1-5.

PROJECT - DEVELOPMENT - DESIGN - RESEARCH—Fifteen years' experience in process and equipment design, development and research. Broad experience in chemical, mechanical, and civil engineering. Good electrical knowledge. Several languages. Seeking responsible position in production engineering or management. Box 2-5.

CHEMICAL ENGINEERING EXECUTIVE—advanced degrees, P.E. Age 35. Well-rounded practical background plant engineering, research, development, project and process design. Desires administrative responsibilities at staff level. Prefers operating chemical company New York-New Jersey-metropolitan area. Present income \$10,000+. Box 3-5.

PRODUCTION SUPERINTENDENT—Organic chemicals and bulk pharmaceuticals. Nineteen years' experience with process equipment, union labor and production supervisors. Excellent background in development of new products and processes. Age 39. Résumé on request. Box 4-5.

DESPERATE FOR Ph.D. CHEMICAL ENGINEER, M.Ch.E., P.E. WANTS POSITION with company allowing him to do doctoral research on job. Thirteen years' experience—research, development, design, production, project. New York City. Will sign contract. Box 5-5.

ENGINEERING MANAGER, M.S.Ch.E.—Thirteen years' successful experience supervising and coordinating development, design and production functions, large scale organic chemicals. Seeks line or staff responsibility with diversified manufacturer in Northeast. \$12,000. Box 6-5.

SITUATIONS WANTED

(Continued)

CHEMICAL ENGINEER, B.S.Ch.E. 1951.—Age 26. Five years' diversified experience as production and project engineer, experienced in maintenance and instrumentation. Desire responsible position in production or development. Eastern or Northern location preferred. Box 7-5.

PLANT ENGINEER—Ten years' diversified experience, including project engineer, equipment design, new construction, maintenance and cost estimating at management and supervisory level. Specialize in getting things done right and on schedule. Box 8-5.

LATIN AMERICA—B.S.Ch.E. 1955. Age 28. American citizen. One year's experience in production. Desires a permanent position in Latin America. Will train if necessary. Speak Spanish fairly. Family, veteran. Box 9-5.

PRODUCTION ADMINISTRATIVE POSITION—B.S.Ch.E. (Tau Beta Pi), M.B.A. (Production Management). Age 34. Seeks administrative position in chemical or allied industry. Nine years' experience in process engineering, construction and plant management. Ex-naval officer. Box 10-5.

CHEMICAL ENGINEER—Ph.D. 1948; with extensive academic experience desires change to challenging industrial position. At present teaching and head of department abroad. Formerly assistant professor at leading U. S. school. Broad industrial and academic research experience, industrial consulting. Mass and heat transfer operations, thermodynamics. Age 33, family. Available August. Box 11-5.

CHEMICAL ENGINEER—B.Ch.E. 1953, age 34. Technical and economic process evaluation experience. Desires pilot plant or production scale research assignments to use strong mathematical and statistical background for cost reduction and production improvement. Box 12-5.

CHEMICAL ENGINEER—M.S.Ch.E. seeks responsible position in process research and development. Five years' experience in process design, economic evaluation, pilot plants, and catalysis in petroleum and petrochemical fields. Age 32, veteran, married. Box 13-5.

CHEMICAL ENGINEER—B.S.Ch.E. 1953. Age 30, married, veteran. Desires to relocate with company offering responsible position. Experience includes organic chemicals manufacture and petroleum field. Present income $8,000. Box 14-5.

RESEARCH AND DEVELOPMENT ENGINEER—Ph.D. Age 33. Experience in teaching, oil-shale processing, fluidized solids reactors, high temperature processes, non-ferrous metals. Interested in development supervisory, or staff advisory position. Minimum salary $12,500. Box 15-5.

CHEMICAL ENGINEER—B.S.Ch.E. Age 30, married, veteran. 3½ years' new process development, current process improvement and plant start-up. Desires position in process and development with progressive company. Box 16-5.

TECHNICAL SERVICE ADMINISTRATOR—Age 38, B.S.Ch.E. Licensed professional engineer New York. Experienced heavy chemicals. Interested in executive employment involving coordination or engineering, development, and production with sales effort, and in managing technical sales service staff. Box 17-5.

PROJECT ENGINEER—M.S.Ch.E. Eight years' sound technical background in plant and equipment design, economic evaluations, purchase and contract negotiations, construction supervision. Present project responsibility exceeds $3,000,000. Desire responsible supervisory position. Age 30, veteran, family. Box 19-5.

DIRECTOR OF INSTRUMENTATION—Well known instrument engineer, with fourteen years' responsible experience in petrochemical industry, would like to organize your corporate instrument program for maximum benefits of automation. Box 20-5.

ECONOMIC PRACTICES IN PROCESS INDUSTRIES FEATURED AT ALL-DAY PHILA-WILM. MEETING

Major One-Day technical program is held, also presentation of Zeisberg student awards for outstanding chemical engineering report writing.

The "Experience in Industry Symposium" of the Philadelphia-Wilmington local section and the School of Engineering of the Univ. of Penn. broke all previous records for these annual sessions with over 600 registrants. Held at the University Museum on the Penn Campus on April 17, the topic was "Economic Practices in the Chemical and Petroleum Industries," seven speakers presented various carefully integrated aspects of the problems.

A major highlight of the day came when A. E. Lawrence, Du Pont, presented the concept of "roll-up costs." Roll-up costs is the name given to accumulated costs of end-products expressed in terms of the basic elements so that the effect of variation in each element upon the end-product cost can be readily determined.

The especially interesting analysis that a product, in order to sell, must have a value greater than its cost, was made by F. F. Ogden, Atlas Powder. Thus manufacturers are definitely limited in their control of product prices. However, the manufacturer can, and often does, find an application for his product that is special and out of the ordinary, and where the value of his product is definitely greater than its cost to the buyer. In this way he can sell products which do not normally have a value greater than cost.

The complex problems involved in Financing The Plant, whether an expansion or an entirely new enterprise, were analyzed by W. J. Price and K. Finsterbusch, Stone & Webster. Present trend for expansions seems to be away from equity financing (common and preferred stocks) and more toward debt financing (bank loans, mortgage bonds, debentures). An important fact is that over the last few years some two-thirds of the capital for plant expansion has come from within the companies themselves and not from outside capital sources.

Examination of so-called direct and indirect cost factors shows that few

ANNUAL ZEISBERG MEMORIAL AWARDS

The two winners of this year's Zeisberg awards were honored at the meeting luncheon. First-prize winner was C. A. Bolez, a senior chemical engineering student at Lehigh Univ., and second-prize winner was A. L. Stockett, also a senior in chemical engineering at Lehigh.

The award is presented each year to the students from 8 schools in the area of the Philadelphia-Wilmington Section who submit the best written reports for their regular class and laboratory work in chemical engineering. The awards honor the memory of F. C. Zeisberg, former president of A.I.Ch.E., and a man long concerned with good report writing by young engineers. The participating schools are: Bucknell, Drexel, Lehigh, Lafayette, Princeton, Delaware, Pennsylvania, and Villanova.

J. P. Mays (r.), Atlas Powder and chmn. of award committee, congratulates first prize winner Bolez while second prize winner Stockett and sponsor-professor L. B. Andersen of Lehigh look on.

LEFT, five of the seven speakers: l. to r., Moody, Knox, Kulp, Ogden and Price. RIGHT, Committee Chmn. (rear, l. to r.) J. P. Mays, Zeisberg Award, R. H. Parker, registration, J. R. Caddell, general chmn., and T. S. Mertes, publicity. (Front, l. to r.) A. E. Humphrey, arrangements, W. E. Osborn, printing, J. A. Liontos, finance, and J. J. Hur, program.

H. P. Kulp, Sun Oil, talks to the packed meeting on the subject of "Why Accounting?"

items can be classed as direct costs. H. R. Moody, Rohm and Haas, speaking on "Plant Operating Costs," showed that product cost sheets are compromises, and where process control is the prime interest, time and effort can be saved by compromising precision in less significant cost areas.

The information-packed program also included talks on "Why Accounting," by H. P. Kulp, Sun Oil; "Plant Investment," by L. C. Knox, Catalytic Construction; and "Economic Analysis," by J. C. Martin, Atlantic Refining. Presiding over the sessions were: W. E. Osborn, morning, and C. H. Collier, Jr., afternoon.

—T. S. Mertes

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STUDENT CHAPTERS OF INSTITUTE IN REGIONAL CONVENTIONS

MIDDLE-ATLANTIC STUDENTS MEET AT PENN STATE

Over 100 student delegates from 12 regional schools gather for Seventh Annual Conclave April 6 and 7.

The Penn State Chapter of A.I.Ch.E. acted as hosts for students from Drexel, Carnegie Tech, U. of W. Va., U. of Pitts., Princeton, Villanova, Bucknell, Johns Hopkins, U. of Maryland, U. of Penn., and U. of Virginia. In addition to the student delegates, many industry engineers were present.

The highlight of the meeting was the presentation of student papers. Each school was permitted to submit one paper, and they were presented in simultaneous sessions on Saturday morning, with the four prize-winning papers being presented again on Saturday evening.

First prize of $50 went to W. C. Parker, Princeton, for his paper, "Algae as a Potential Source of Food." Second prize of $25 went to T. Smith, Johns Hopkins—"Pressure Drop Through a Packed Bed." Third prize, also $25, went to E. Fleck, Villanova—"The Effect of Clearance of Anchor Agitators on Power and Heat Transfer." And fourth prize of $10 went to H. Windsor, Bucknell—"Diffusion of Gases Through Parans Media."

Students and guests also toured the Penn State nuclear reactor, the water tunnel, the Petroleum Refining Laboratory and the Unit Operations Laboratory. At the all-convention luncheon, C. Hosler of Penn State's Meteorology Department, spoke on "Predicting and Controlling the Weather," and at the banquet, R. Halik, Socony Mobil Laboratories, spoke on the "Chemical Engineer's Place in Nuclear Development."

—A. Rose

U. OF ALABAMA IS SITE OF SOUTHERN REGIONAL STUDENT CHAPTER MEETING

"Evaporation" and "Filtration and Diffusion" highlight technical aspects of three-day convention April 18, 19 and 20.

Representatives of the A.I.Ch.E. student chapters at 10 southern universities gathered on the campus of the U. of Alabama for a three-day business, technical and social get-together. In addition to host Alabama, students came from: Alabama Polytech, Clemson, L.S.U., U. of Louisville, Miss. State, North Carolina State, U. of South Carolina, U. of Tenn., and Tulane.

After a social "smoker" on the 18th, the convention got down to the serious business with the presentation of student papers on the 19th, the awards and the all-convention banquet.

On Friday, guest speakers took over, discussing important technical subjects. H. E. Jacoby, Process Equipment Division, Chicago Bridge and Iron, went into "Evaporation," and G. E. Sanford, Improved Paper Makers Machinery Corp., presented the subject of "Filtration and Diffusion."

A lively and highly informative panel discussion was presented by the Institute of Pulp and Paper Chemistry, Appelton, Wisc., which included a plant trip to the nearby plant of the Gulf States Paper Corp.

An informal dance wound up the three-day meeting on a social note.

—K. W. Coons

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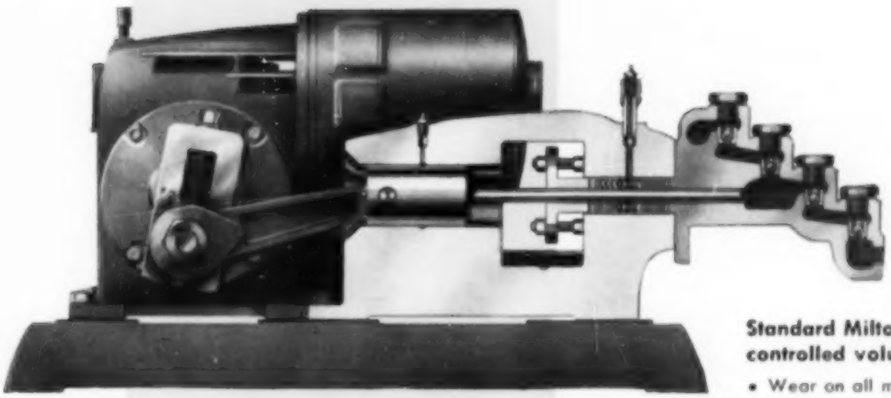
news and notes of A.I.Ch.E.

Admissions: Even though every member of the A.I.Ch.E. had to go through it, one of the least understood functions of the A.I.Ch.E. & one of the least understood committees is the Admissions Committee. . . . In the past C.E.P. has carried articles from Admissions Committee chairmen explaining functions, operations, & problems, but a review of some of the difficulties might be in order now, especially since Local Sections are more & more counseling & guiding chemical engineers into A.I.Ch.E. membership. Late last year we sent to all committee members, Local Section officers, counselors, etc., an article written by the then chairman of the Admissions Committee, Don Spitzli, on some of the problems of the committee, & many suggested that we print the article. Rather than reproduce this two-page report, we are abstracting some of the more pertinent clauses. The Admissions Committee this year is under the chairmanship of Earp Jennings & continuing the fine work that the committee always does in screening the some 1,800 applications that come its way. Membership requirements in A.I.Ch.E. are stringent & the committee is bound by the Constitution in very specific ways. All prospective members & Membership Committee men should be familiar with the constitutional provisions . . . For instance, where the constitution requires 6 years of experience, the committee will not accept 5¾ years . . . they are that tough . . . Then 'engagement in chemical engineering' proves to be a stumbling block for many . . . The committee has only the description of the job given by the candidate & by his references to go on . . . Since each case is different, the consistency with which the committee interprets 'engagement in chemical engineering' is amazing. As pointed out by the Admissions Committee, however, the normal applicant does not understate his case . . . According to Spitzli's report, "Consequently the overmodest applicant or he who uses gross exaggeration does himself no good. The former may be rescued by good references; the latter may be trapped by conscientious references. For example, it would amaze the membership to know how many of our applicants, through carelessness or intent, set forth a degree or training which their college will not confirm." In the matter of references, the committee requires good substantiating statements from men who know the applicant's work. A professor who knew the candidate in school 15 years ago or the prominent figure who has talked only casually to the applicant are not helpful. The straightforward application with references from persons with direct knowledge of the candidate gives little trouble. . . . In order to achieve the purpose of our organization, only ethical, capable chemical engineers must make up its membership. . . . In the counseling of a prospective member of the A.I.Ch.E., it is most helpful to discuss with him the class of membership for which he would be eligible on the basis of his experience . . . It helps in advising an applicant to tell him when his case is borderline & when he should apply for one of the lower levels of membership . . . Where the committee feels that a higher grade can be obtained by the candidate, he is so told.

Memo to Student Chapter Counselors: Worried about attendance at Student Chapter Meetings? Here is a leaf from a notebook from the University of Texas as reported by J. J. McKetta, Jr., Chairman of the Department of Chemical Engineering: "Our present Student Chapter has 375 members out of a total number of 450 chemical engineering students . . . What is more important is the fact that we have over 35% of the actual members attending each meeting . . . Here is the way it is done: (1) we have a speaker each meeting who discusses the type of work a student may get into after he gets out of school & (2) (this one is the better drawing card, I guess) the local sororities are contacted for the best looking girl . . . This girl is to be considered as 'Miss Chemical Engineer' of the year . . . Each meeting one girl is introduced to the group; that is, the group is told that she is a candidate for Miss Chemical Engineer. Then a drawing is held. The winning number corresponds with that on a Student Member's membership card. Then this student gets to date this beautiful girl sometime during the next week."

Correction: In February, talking about nominations, we gave some wrong figures, for which we apologize. We reported that the Nominating Committee has been asked by Council by-laws to bring in nominees 18 weeks prior to the annual meeting, in order that the candidates' records might be seen early in the year . . . actually this is 20, not 18, weeks . . . The second error made was the deadline for nomination by petition . . . this is 9 weeks instead of 7.

F. J.V.A.



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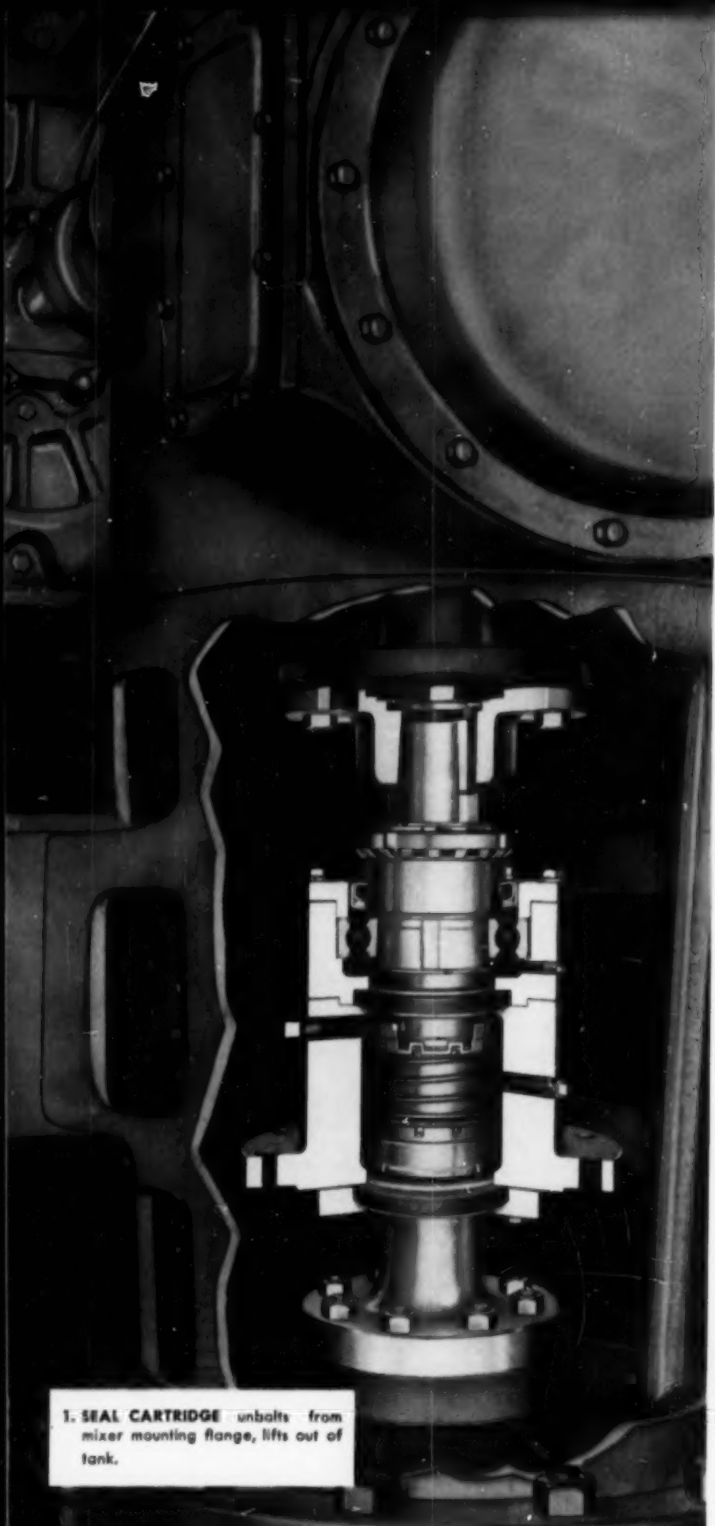

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